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A PRELIMINARY REPORT ON THE USE OF CESIUM CHLORIDE IN CONTRAST RADIOGRAPHY

by

Robert Shapiro

In a previous communication, the author (1955) discussed the use of zirconium compounds for contrast radiography. These compounds proved to be unsatisfactory in man because of the relatively low atomic number of zirconium, *i. e.* 40. In an effort to obviate this difficulty, cesium was substituted for zirconium. The purpose of this paper is to report our experience with cesium chloride as a radiopaque contrast medium.

In 1860, BUNSEN and KIRCHHOFF, using the recently invented spectroscope, observed two new sky-blue spectral lines in a sample of mineral water from Dürkheim. They, therefore, suggested the name cesium (L. coesium, sky-blue) for the new element. Cesium is element number 55 with an atomic weight of 133 and a valence of 1. The element itself belongs to the alkali series of metals and hence chemically resembles rhubidium and potassium. Silver-white or golden-yellow in color, it is the most electropositive as well as the softest of all metals. Cesium is not found naturally in the metallic state but commonly occurs as a salt or oxide. Its principal mineral sources are lepidolite, rhodozite and pollucite (a hydrated silicate of aluminium and cesium). Cesium is used industrially in photoelectric cells, as a 'getter' in radio tubes and as a catalyst in the hydrogenation of various organic compounds (LEGAL 1946).

Although cesium is normally present in various plants and animals, it is toxic to many biochemical systems. Thus SEIFRITZ (1949) reported

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pathological changes in the proto-plasm of the slime mold and ALHA (1946) noted toxic changes in fungi following the addition of cesium salts. Likewise, FOLLIS (1943) produced generalized convulsions as well as renal and myocardial necrosis by feeding cesium to rats on a potassium deficient diet.

There is good evidence to suggest that cesium resembles rhubidium and potassium biologically as well as chemically:

1) GALLEGO and DENO (1947) reported depolarization of frog nerve tissue in 0.11 molar solutions of Cs, Rb, K, NH_4 and Li.

2) LOVE and BURCH (1953) demonstrated that Rb^{86} and Cs^{134} are both concentrated in red blood cells to the same extent as K.

3) HARNACK and DIETRICH, as well as BRUNTON and CASH, reported paralysis of frog muscle due to RbCl and CsCl.

4) BOTKIN produced cardiac standstill following the intravenous injection of RbCl, CsCl and KCl.

HANFORD (1903) studied the toxicity of CsCl in frogs and various mammals. Although the degree of toxicity varied with the species, parenteral CsCl was toxic to frogs, rabbits, cats and dogs alike. The subcutaneous injection of 0.5 to 2.0 g of CsCl/kg of body weight produced vomiting and diarrhoea followed by progressive paralysis and death. The intravenous injection of 0.75 g of CsCl/kg of body weight resulted in cardiac standstill.

On the other hand, COCHRANE and his co-workers (1950) studied the acute intraperitoneal toxicity of various cesium salts and found them to be relatively non-toxic with the exception of CsOH as appears from the table below.

Table (after COCHRANE)

Compound	LD_{50} of compound mg/kg	LD_{50} of metal mg/kg
CsCl	1,500	1,118
CsBr	1,400	874
CsI	1,400	715
$CsNO_3$	1,200	817
CsOH	100	89

They also noted that CsCl did not inhibit the adenosine triphosphatase activity of mouse liver in vitro.

Materials, methods and results

In the present study the author investigated the acute intravenous toxicity and excretion of CsCl in rabbits and dogs. CsCl is rapidly excreted principally by the kidneys (80 to 85 %) and to a lesser extent (15 %) by the intestinal tract. Similar findings were noted by GRAHAM

Fig. 1. Bronchogram in a dog with unthickened CsCl 30 %, showing rapid alveolar filling.

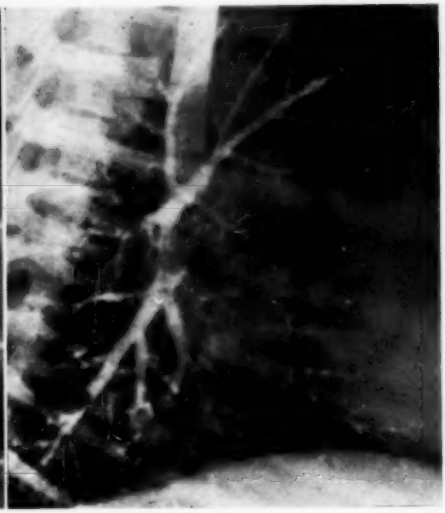

Fig. 2. Bronchogram in a dog — CsCl 30 % with carboxy-methyl cellulose 5 %. Note lack of alveolar filling.

and WRIGHT (1933). By trial and error, it was found that a 30 per cent solution of CsCl provided satisfactory radiopacity. The intravenous injection of 700 mg of this compound produced hyperactive reflexes and increased mastication but no other obvious toxic effects. Following the injection of 1,500 mg, several dogs exhibited extrasystoles and diarrhoea. On the other hand, the intravenous administration of 3,000 mg of 30 % CsCl consistently resulted in increased irritability, generalized convulsions, and gasping respirations, followed by apnoea and cardiac standstill. Death invariably occurred within a few minutes after injection.

This report is principally concerned with the utilization of CsCl for bronchography and hysterosalpingography.

Bronchography. Twelve dogs were anaesthetized with intravenous veterinary sodium nembutal after preliminary fasting. The trachea was intubated with a rubber catheter, and 10 to 20 cm^3 of 30 % CsCl were injected into the catheter without any evidence of immediate or late toxicity. In all cases, the radiopacity was good. However, the CsCl had a marked tendency to pass on to the alveoli (Fig. 1). In addition, the CsCl was completely absorbed from the bronchopulmonary tree within five minutes. This made spot-filming essential and precluded conventional radiography.

Fig. 3. Hysterogram in a dog with CsCl 30 %.

In an effort to circumvent these difficulties, several thickening agents were employed, *i. e.* sodium carboxymethyl cellulose 3 to 8 % and polyvinyl pyrrolidone 3 to 6 %. The thickened solutions tended to remain in the larger bronchi and were absorbed somewhat more slowly, *i. e.* 8 to 15 minutes (Fig. 2). However, the increased viscosity made injection more difficult.

Following preliminary animal studies, left upper lobe segmental bronchography was performed on two human subjects, using 30 % CsCl thickened with sodium carboxymethyl cellulose 3 %. After preliminary sedation with seconal and topical anaesthesia with pontocaine 1 %, CsCl was instilled through an intratracheal catheter. In both cases, although the radiopacity was quite satisfactory, the CsCl was rapidly absorbed from the tracheobronchial tree within three minutes. In addition, both patients complained of severe left upper chest pain at the time of injection. Both patients were operated upon the day after bronchography at which time the surgeon found a very wet lung. In the author's experimental and clinical experience, all hypertonic aqueous solutions are very irritating to the respiratory epithelium, producing not only hyperemia but also varying degrees of epithelial injury.

Hysterosalpingography. After preliminary fasting, two dogs were anaesthetized with intravenous veterinary sodium pentothal; 10 cm³ of CsCl 30 % were then injected through the cervical os. Again, the radiopacity was quite satisfactory (Fig. 3). The material was fairly rapidly absorbed from the peritoneal cavity without any obvious immediate or late toxicity.

Acknowledgments

The author is deeply indebted to Dr. Dominick Papa for his untiring cooperation. The photography was done by Mr. Tom Woodward.

SUMMARY

The pharmacology of cesium salts is briefly reviewed. Preliminary studies using CsCl for bronchography and hysterosalpingography are presented.

ZUSAMMENFASSUNG

Die Pharmakologie der Cäsiumsalze wird kurz überblickt. Präliminäre Studien mit CsCl für Bronchographien und Hysterosalpingographien werden vorgelegt.

RÉSUMÉ

L'auteur rappelle brièvement la pharmacologie des sels de césium et présente des études préliminaires sur l'emploi de CsCl en bronchographie et en hystéro-salpingographie.

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SIZE OF NORMAL KIDNEYS

by

Hans Moëll

Measurement of the size of the kidneys as they appear in the roentgenogram is of importance in the investigation of diseases involving the renal parenchyma (TILLGREN & HÅKANSSON 1929, KLEEBERG & DREYFUSS 1946 and OLLE OLSSON 1954). However, proper evaluation of such measurements requires knowledge of the ordinary roentgenographic size of the kidneys.

Anatomic investigations. POURTEYRON (1872) found the following average measurements for 86 pairs of kidneys studied post mortem:

		Length	Width			Length	Width
Women	right	10.8 cm	5.9 cm	Men	right	11.4 cm	6.5 cm
	left	11.6 cm	6.0 cm		left	12.0 cm	6.7 cm

HOFFMAN (1877), whose material consisted of 320 subjects, found the right kidney to be on the average 11.2 × 5.6 × 3.8 cm, and the left 11.8 × 5.5 × 3.5 cm. ROLNICK (1949) gave 12 × 6 × 3.9 cm, and BOYD (1953) gave 11 × 6 × 3 cm. They did not state the sizes of their materials.

As to the weight of the kidneys, POURTEYRON (1872) gave 141 g for the right, and 152 g for the left in men, and 115 and 124 g, respectively, in women.

THOMA (1882) found the left kidney to be 5 to 7 per cent heavier than the right, and the total weight of both kidneys to be 316 g in men and 292 g in women, figures which ROESSLE & ROULET (1932) described as too high. They found the kidneys to weigh 260 to 280 g in men aged 20 to 55 and 240 to 260 g in women of corresponding ages. They also showed that the kidney does not change in weight until after the age of 55. Other authors

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(GREENWOOD & BROWN 1913, WALD 1937), however, found values approaching those given by THOMA.

To summarize it may be said that all of these investigators found that the left kidney was larger than the right and at the same time somewhat longer and narrower, and that in women the kidneys were somewhat smaller than in men. These measurements cannot, however, be strictly applied to the roentgenographic appearance of the kidneys.

Roentgenographic investigations. BRAASCH & MERRICKS (1938) measured the kidneys in 100 urograms and found an average size of 12.0 × 6.0 cm. They made no distinction between the right and left kidney or between men and women. KÖHLER (1939) found an average width of 6.5 cm and quoted STRÄTER, who gave a length of 13.3 cm. In his clinical studies of renal function of nephrectomised patients SCHROEDER (1944) measured the kidneys in 25 healthy women and 25 healthy men in urograms and gave the following figures:

		Length	Width			Length	Width
Women	right	12.9 cm	5.9 cm	Men	right	13.4 cm	6.3 cm
	left	12.9 cm	6.0 cm		left	13.7 cm	6.2 cm

KLEEBERG & DREYFUSS (1946) found the normal size of kidneys in the conventional roentgenogram to be 10 to 12 × 5 to 6 cm. No description is given of the number of the cases they studied or the technique used. BILLING (1954) measured the length of 100 kidneys and found 99 to be 11 to 13 cm in length and one 14 cm. The focus—film distance was given as 100 cm.

SCHROEDER (1944) is thus the only one to make a distinction between the right and left kidney and between women and men.

Personal investigation

Material and method. The material consisted of 115 apparently healthy soldiers, not examined in the fasting state, *i. e.* eating and drinking ordinarily. It also included a clinical series of 25 women and 25 men, aged 20 to 55 and examined in the fasting state. None of the patients was known to have had renal disease, and renal function tests revealed no signs of a pathologic condition.

The patients were examined in the supine position and films were taken in the standard projection and also at an angle of about 20° to either side. The measurements were made only in the a. p. films, the oblique films only being obtained for guidance; focus—film distance = 100 cm.

The maximum length and maximum width of the kidney were measured. Since the kidneys are normally slightly rotated in relation to the

frontal plane, the widths measured in the roentgenogram will be somewhat smaller than in reality.

Significance of object—film and focus—film distance. Measurements showed that between a distance of 5 to 9 cm from the surface of the table a change of 1 cm of the object changed the linear enlargement by 1.3 mm. Variations in the focus—film distance could be determined through the formula for equilateral triangles.

Size of the kidneys related to body surface. KLEEBERG & DREYFUSS (1946) pointed out that 'body size and volume must be taken into consideration since a large body naturally harbors larger kidneys than a small one and the shape of the kidney, like, for example, the shape of the heart, corresponds to general body build'. SMITH (1951) found the absolute values obtained by various renal function tests to be fairly closely correlated with body surface and that body surface is the best factor available for correlating renal function.

The total area of the kidneys was also correlated with the m^2 body surface. In order to be able to compare the areas of various kidneys, and of a given kidney from one occasion to another, the areas of the kidneys were measured planimetrically.

For practical reasons, it is, however, not possible to include planimetry in the routine examination of the kidneys. The area of the kidney was therefore also measured by the formula for determining the area of an ellipse ($\pi \times$ half the length $\times$ half the width). No difference was found in the area of the kidney, as determined by these two methods.

The results obtained in the present investigation are recorded in the following tables.

Military men

♂	Length	Width	Length	Width
	right		left	
s	12.8 cm 0.87	6.0 cm 0.39	13.5 cm 1.01	6.2 cm 0.47
	Area right	Area left	Total area	Total area / m^2 body surface
Planimetry	61.0	67.4	128.4	69.2
s	6.33	7.77	12.94	6.44
$\pi \times a \times b$	60.4	66.4	126.7	68.2
s	6.70	7.55	12.37	6.32

Clinical material

	Length	Width	Length	Width	Area right	Area left	Total area	Total area
	right		left					m^2 body surface
	cm	cm	cm	cm	cm^2	cm^2	cm^2	cm^2
♀	12.4	5.9	12.8	6.1	58.1	61.2	119.3	72.2
s	0.66	0.37	0.77	0.38	5.3	6.4	9.7	6.6
♂	12.7	6.3	13.2	6.4	62.8	66.8	129.6	70.1
s	0.78	0.49	0.82	0.55	7.1	7.6	13.8	5.4

The total area of the kidneys in females was smaller than in males with a probability of 99 per cent but, on correlation with m^2 body surface, this difference was not statistically significant. These figures also showed that there was no difference between subjects examined in the fasting state (the clinical material) and the remainder.

A comparison with SCHROEDER's (1944) values produced the following:

	Length	Width	Length	Width	Area right	Area left	Total area	Total area
	right		left					m^2 body surface
♀	cm	cm	cm	cm	cm^2	cm^2	cm^2	cm^2
SCHROEDER	12.9	5.9	12.9	6.0	58.7[1]	60.2[1]	118.9	—
MOËLL Clin. mat.	12.4	5.9	12.8	6.1	58.1[2]	61.2[2]	119.3	72.2
♂								
SCHROEDER	13.4	6.3	13.7	6.2	67.3[1]	68.5[1]	135.8	—
MOËLL	12.8	6.0	13.5	6.2	61.0[1]	67.4[1]	128.4	69.2
Mil. mat.					60.4[2]	66.3[2]	126.7	68.2
Clin. mat.	12.7	6.3	13.2	6.4	62.8[2]	66.8[2]	129.6	70.1

[1] The area measured planimetrically. [2] The area measured by the formula $\pi \times a \times b$.

If allowance is made for the roentgenographic enlargement, good agreement will also be found between the size of the kidneys as measured in the roentgenogram and that found at autopsy.

Conclusions

The following observations may be made from the analysis:

1. In a clinical material the right kidney measures 12.7 × 6.3 cm, the left 13.2 × 6.4 cm, the total area being 129.6 cm², and the area per m² body surface 70.1 cm² in men. The corresponding figures for the women are 12.4 × 5.9 cm, 12.8 × 6.1 cm, 119.3 cm² and 72.2 cm².
2. The kidneys are smaller in women than in men.
3. In both sexes the left kidney is somewhat larger than the right.
4. No difference was found between the sizes of the kidneys in subjects examined in the fasting state and the remainder.

SUMMARY

An investigation is presented on the roentgen size of healthy kidneys to be used as controls in an investigation of changes in the size of the kidneys in diseases involving the renal parenchyma.

ZUSAMMENFASSUNG

Eine Untersuchung über die röntgenologische Grösse gesunder Nieren wird vorgelegt. Sie soll als Kontrollmaterial bei einer Studie über die Veränderungen der Nierengrösse bei Erkrankungen, die das Nierenparenchym angreifen, benutzt werden.

RÉSUMÉ

L'auteur présente un travail sur les dimensions radiologiques de reins sains, devant servir de base de comparaison pour un travail sur les modifications des dimensions des reins au cours de maladies intéressant le parenchyme rénal.

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AN ELECTRIC PNEUMOGRAPH

by

Björn Nordenström

In many instances a simple pneumographic device is of value for recording the respiratory movements of the thoracic wall. In the utilization of electrokymographic respiratory studies for roentgen diagnosis, for example, it is important to have a synchronous record of the chest wall movements by pneumography. Continuous electrokymographic recording of the mechanical events of respiration with tracings of the movements of the diaphragm, chest wall and of the variations in the roentgen density of lung tissue can then be correlated with the pneumographic tracings.

The pneumograph devised for this purpose consists of a flexible electric battery (Fig. 1). A piece of soft rubber tubing about 15 cm in length, is plugged at each end by stopcocks. Attached to the end of one of the stopcocks is a piece of copper, and to the other a piece of zinc. The rubber tubing is filled with a diluted solution of sulfuric acid and the system is closed by turning the stopcocks. A piece of string is tied to each of the stopcocks and the flexible battery is stretched slightly and the strings tied around the chest. An electrocardiagraphic cable is then connected to each of the stopcocks.

During the respiratory excursions of the chest wall, the internal resistance of this flexible battery is changed. The magnitude of the deflections on the recording paper can easily be adjusted by means of the amplifying circuit of the electrocardiograph.

The pneumograph has been used together with an Elema direct writing recorder provided with one electrocardiographic, one electrokymographic and one pressure recording channel. For this purpose, the electrocardiographic channel was used for the pneumographic recording.

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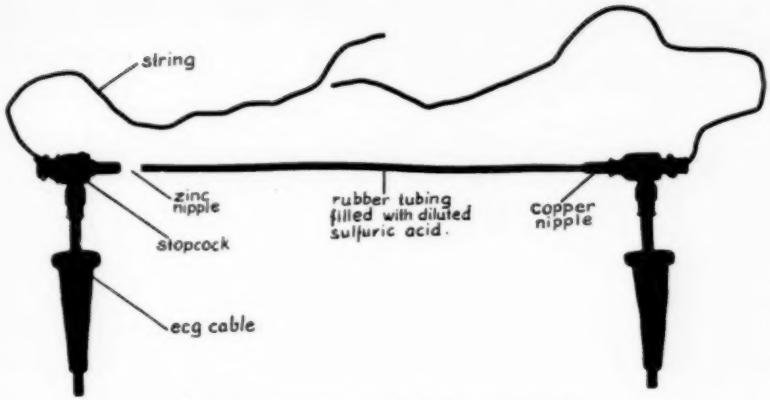

Fig. 1. Construction of the pneumograph.

Fig. 2 shows different possibilities of recording mechanical events of respiration in a dog. A_1 represents an electrokymographic recording of the diaphragmatic movement, B the intra-tracheal pressure variations and C the recording of the movements of the chest wall by means of the pneumograph. Arrows indicate the beginning of inspiration. Curve A_2 in Fig. 2 represents a densographic recording of the variations in transmission of the roentgen rays over part of the lung obtained by means of the electrokymograph. In this recording, variations due to pulmonary arterial pulsations are superimposed on the respiratory variations. Finally, A_3 is an electrokymogram of the movements of the chest wall.

The different mechanical events of respiration recorded in this way have been found to be in close relationship to each other. This may be more easily seen in Fig. 3, representing recordings of the diaphragmatic

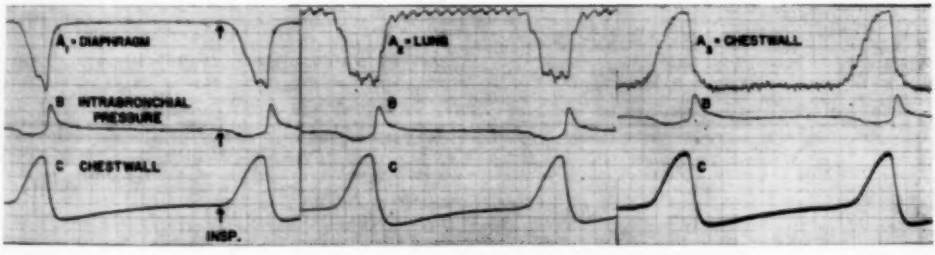

Fig. 2. Recordings of mechanical events of respiration in a dog. Tracings A_1, A_2 and A_3 are obtained by means of the electrokymograph. Tracing C is obtained by means of the pneumograph.

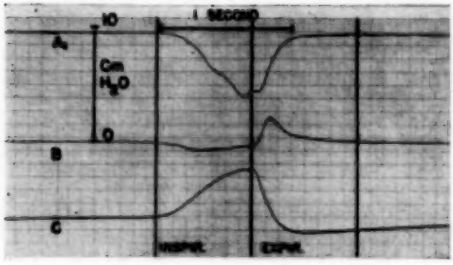

Fig. 3. A close relationship is found between the movements of the diaphragm (A_1), the intrabronchial pressure variations (B) and the movements of the chest wall (C) in the dog.

movement, intrabronchial pressure and the movements of the chest wall in a dog.

This synchronicity of the events seems to make it possible to utilize the pneumograph as a timer of respiratory events for other electrokymographic studies, such as investigations of disorders of diaphragmatic function.

The pneumograph has been tested in a human subject. The recordings of the movements of the chest wall have been found to be essentially the same as in the dog. Such a tracing is shown in Fig. 4, curve 2. The sharp downward movements of the curve, indicated by arrows, represent the stage of rapid inward movement of the chest wall against the closed glottis in voluntary cough. Curve 1 in the same tracing represents a tracing of the pressure variations within the pneumograph. Some correlation seems to exist between the pressure changes within the rubber tubing and the pneumographic tracing during quiet respiration. This relationship is discontinued to a large extent during cough.

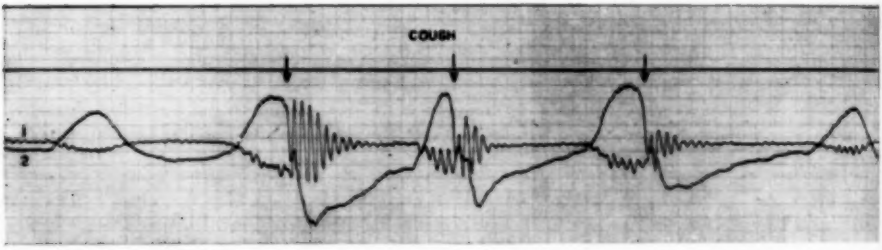

Fig. 4. Pneumongraphic tracing of the chest wall in man (curve 2) and simultaneous recording of pressure variations in the rubber tubing of the pneumograph (curve 1). The correlation between the pneumographic and the pressure tracing is largely discontinued during cough.

This investigation was carried out during the tenure of a James Picker Foundation Fellowship in Radiological Research.

SUMMARY

A pneumograph for recording respiratory movements of the chest wall is described. It has been used as a timer for electrokymographic recordings of the respiratory movements of the diaphragm, chest wall, and the variations of the transmission of roentgen rays through the lungs during respiration.

ZUSAMMENFASSUNG

Es wird ein Pneumograph zur Aufzeichnung der Atmungsbewegungen des Brustkorbes beschrieben. Er wurde als Zeitnehmer für elektrokymographische Aufzeichnungen der respiratorischen Bewegungen des Zwerchfelles, des Brustkorbes und der Variationen der Leitung der Röntgenstrahlen durch die Lungen während der Atmung verwendet.

RÉSUMÉ

L'auteur décrit un pneumographe pour enregistrer les mouvements respiratoires de la paroi thoracique. Il a été utilisé comme chronographe pour les enregistrements électrokymographiques des mouvements respiratoires du diaphragme, de la paroi thoracique et des variations de la transmission des rayons roentgen à travers les poumons pendant la respiration.

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MECONIUM PERITONITIS

Report of a case

by

Jack Lester

Meconium peritonitis is an aseptic peritonitis developing in late intra-uterine life during or just after delivery when meconium enters the peritoneal cavity through an intestinal perforation.

The first case on record was described by SIMPSON in 1838; since then only about 100 cases have been reported, the most recent one by MOOKHERJEE in 1955. No cases have been published by Scandinavian authors.

On the other hand, meconium ileus, which is usually due to pancreatic fibrosis, has been reported with increasing frequency during recent years. Thus, the roentgenographic appearance of this disorder was described by THOMSEN and VESTERDAL in 1954.

Meconium, which is a sterile mixture of epithelial cells, mucin, salts, fats, and bile, is formed when the foetus begins to swallow amniotic fluid and is present in the upper part of the small intestine in the third month of intra-uterine life. The presence of meconium excites intestinal peristalsis, and the substance is propelled down through the intestine. Blending with the gastric and pancreatic juices begins in the fifth month, and in the sixth month the colon is normally also filled with meconium.

According to BOIKAN (1930), the intestinal perforation in meconium peritonitis is due to obstruction caused by atresia, volvulus, or string formations, in about one half of the cases. Meckel's diverticulum has been reported to be the exciting cause in two cases (MOOKHERJEE 1955; BOIKAN 1932). Obstetric or other traumata may occasionally give rise to perforation (ZILLNER 1884). In the remaining cases the disease will be

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associated with pancreatic fibrosis, leading to a putty-like consistency of the meconium and failure of its peristaltic propulsion through the intestine. Accordingly, meconium ileus and, if perforation occurs, meconium peritonitis develop. When the meconium enters the peritoneal cavity, an exudate is formed, and organization rapidly occurs. Matting of the intestinal loops develops, later followed by extensive calcifications in the visceral peritoneum. In the prenatal period the peritonitis is sterile, but shortly after birth secondary infection supervenes.

The characteristic signs are vomiting, abdominal distension, and failure to discharge the meconium. The vomiting is not very violent, but usually begins immediately after birth. The abdomen may become greatly distended. Thus, MITTELMEIER and MOHR (1953) described a case in which the distension offered an insuperable obstruction to delivery, which was not accomplished until perforation had been performed. Absence of normal meconium bowel movement is pathognomonic of the disease.

Cases which are referable to pancreatic fibrosis are usually accompanied by pulmonary signs, particularly cyanosis caused by abundant amounts of tenacious bronchial secretion.

The diagnosis is made by roentgen examination, which should be performed as soon as possible in all suspected cases. The roentgenographic appearance was described in detail by NEUHAUSER (1944, 1946). Free air, often in large amounts, is found in the peritoneal cavity, and as abundant quantities of abdominal fluid are also present, large fluid levels are seen in films taken in the vertical position with a horizontal beam projection. The most characteristic feature is the intra-abdominal calcifications, which occur in the cornified epithelial cells from the meconium and may be visible as early as 24 hours after the perforation. The calcifications may be distributed diffusely in the abdomen, but are often most distinct on the surface of the liver or spleen. If the calcifications are inconspicuous, they are most readily visualized in the lateral view, in which they are projected free of the skeletal system (FRANKLIN and HOSFORD 1952).

In the conventional films the colon does not contain air, and after a barium enema its lumen appears to be very small. This observation has previously been referred to as microcolon (SCHROEDER 1937; ZIMMER 1946), but it appears to be the visualization of a normal colon through which meconium has not yet passed (MCCONOHAY 1945).

The chest roentgenograms are characterized by marked elevation of the diaphragm due to the abdominal distension. In addition, in the presence of pancreatic fibrosis there will often be atelectatic areas due to bronchial obstruction by tenacious secretion or localized emphysema because the secretion may act as a valve (ROSENDAL 1951).

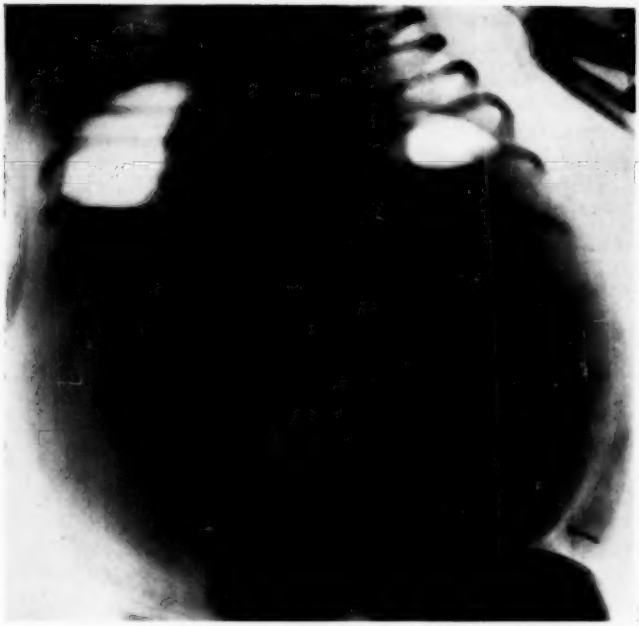

Fig. 1. Pre-operative film in hanging position. Free air and abundant amounts of fluid are present in the peritoneal cavity. Intra-abdominal calcifications, especially in left lower quadrant (↖) and on surface of spleen. Air, but no fluid levels are visible in the small intestine. Following a barium enema, the lumen of the colon is very small (microcolon).

In the treatment surgical measures are indispensable. The perforations must be sutured, and attempts made to remove the tenacious meconium from the small intestine. This may be done by irrigation of the intestine with a trypsin solution, as *in vitro* experiments have shown that the pathologically inspissated meconium may be rendered perfectly liquid by the influence of pancreatic enzymes (Farber 1944).

The prognosis is very bad, but survival has been reported in a few cases during recent years (Franklin and Hosford 1952; Low 1949; Neuhauser 1944; Packard and Reynolds 1951).

Case Report

The patient was a newborn girl admitted to hospital with cyanosis and abdominal distension 1½ hours after uncomplicated delivery at home; weight 3,300 g. On admission, the infant was markedly cyanotic with a greatly distended abdomen; she had vomited slightly and no meconium had been passed. Blood group 0, Rh negative; Coombs' test negative; haemoglobin 143 %, methaemoglobin 0 %.

Conventional films of the abdomen in the hanging position showed abundant amounts of free air in the peritoneal cavity with large fluid levels. There were diffuse intra-abdominal calcifications, especially in the left lower quadrant, and more distinct calcifications on the surface of the spleen; no gas in the colon. The loops of the small intestine were seen in the middle of the abdomen; they were slightly distended, but without fluid levels. Following a barium enema, the colon filled to the lower part of the caecum, but the lumen was very small everywhere, only 4 to 5 mm, as compared with 15 to 20 mm in a normal newborn infant (fig. 1).

A diagnosis of meconium peritonitis was made and laparotomy performed at once. When the abdomen was opened, abundant amounts of air escaped, and meconium and extensive calcifications were revealed in the peritoneal cavity. The loops of the small intestine were adherent and filled with tenacious meconium, and there was a perforation in the distal part of the ileum. No strictures, atresia or other congenital anomalies were present. The perforation was brought to the surface and oral and anal drainage established.

After the operation, attempts were made to overcome the intestinal obstruction by administration of a trypsin solution both through the ileostomy drains and through a stomach tube. However, in spite of oxygen therapy and repeated suction the patient became increasingly cyanotic and died 24 hours after the operation. Autopsy revealed bronchial obstruction by stagnant secretion and atelectasis of the right lung. The pancreas was normal, both grossly and microscopically. It was concluded that the meconium ileus was due to a secretory disturbance.

The patient suffered from a systemic disturbance with increased viscosity of the secretions, a mucoviscoidosis, of unknown origin. A similar case was described by HINDEN in 1950, but the absence of fibrocystic disease of the pancreas is a rare occurrence. It must be supposed that the prognosis would have been poor even if the infant had survived the first critical period after the operation.

SUMMARY

A brief survey of meconium peritonitis is given. The disease is diagnosed roentgenographically from the presence of free air in the peritoneal cavity combined with intraperitoneal calcifications. A case referable to mucoviscoidosis is reported.

ZUSAMMENFASSUNG

Der Verfasser gibt einen kurzen Überblick über die Mekoniumperitonitis. Die Krankheit wird röntgenologisch diagnostiziert durch die Anwesenheit freier Luft in der Bauchhöhle bei gleichzeitiger Anwesenheit intraperitonealer Verkalkungen. Ein Fall, der auf eine Mucoviskoidosis zurückzuführen ist, wird berichtet.

RÉSUMÉ

L'auteur rappelle brièvement ce qu'est la péritonite à méconium. Cette affection est diagnostiquée radiologiquement par la présence d'air libre dans la cavité péritonéale associée à des calcifications intrapéritonéales. Il présente un cas dû à la mucoviscoïdose.

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CELL DIVISION AND NUCLEIC ACID SYNTHESIS IN THE REGENERATING LIVER OF THE RAT

by

Donald B. Cater, Barbara E. Holmes and *Lorna K. Mee*

By using the early stages of liver regeneration in rats subjected to partial hepatectomy, it is possible to investigate separately certain processes of cell growth. The present investigation was undertaken to establish the relationship between DNA synthesis and mitosis and to determine whether any one stage of the cell division cycle was particularly sensitive to the action of roentgen irradiation. This paper includes pooled data of RNA and DNA synthesis and mitotic activity in the regenerating livers of control rats and of rats subjected to irradiation of the liver at 12, 18, 21 and 24 hours after partial hepatectomy.

Materials and methods. Male rats of about 300 g weight were anaesthetised with ether and two lobes of the liver were removed by the technique of HIGGINS and ANDERSON (1931). After the operation they were kept warm and fed on carrots, or bread and sugar. Half an hour before irradiation they were injected subcutaneously with amytal 70 mg/kg. A Maximar 220 kV_p standard treatment machine was used for irradiation, filtered with 1 mm/Al H. V. L. 0.4 mm copper. The dose rate was 150 r per min. The irradiation was delivered over the remaining liver lobes; the rest of the body was shielded, as far as possible, with lead rubber. Rats were injected subcutaneously with 70 μc of P^{32}, three hours before death. They were killed with chloroform, the liver was rapidly removed, a slice fixed in Suza for mitotic counts, and the rest of the liver processed by the methods of SCHMIDT and THANNHAUSER (1945) for RNA and DNA. The inorganic phosphate fraction was extracted in isobutanol by the method of WEIL-MALHERBE and GREEN (1951). P^{32} counts were made with a liquid dipping counter.

The mitotic counts were performed on paraffin sections, 6μ thick, stained with haematoxylin and eosin. A square aperture was placed in the focussing eye-piece of the microscope. This gave a field 110μ square. The mitoses present in 200 fields were counted. The number of liver-cell nuclei in every tenth field were counted. The results are given as a mitotic index, *i. e.* the number of mitoses per 1,000 cells. Usually, 200 fields represents 4,000 to 5,000 cells so that the mitotic index is dependable. The phases of mitosis were recorded.

Submitted for publication 29 March 1956.

In some experiments colchicine 0.7 mg/kg was given by subcutaneous injection 3 hours before death.

In all the radiation experiments two comparable black and white hooded rats were used, one of which was irradiated. In other respects the treatment of the two rats was identical. In experiments carried out during the last 18 months rats were fed on a high protein diet (liver) for 2 days prior to hepatectomy. In certain other experiments white Wistar rats were used. An analysis of variance of the control rats from different breeds and strains indicated that there was no greater variation between different groups than within the groups themselves. Similarly, protein feeding before hepatectomy does not produce an earlier onset of mitosis or increase the mitotic response. The use of amytal as an anaesthetic also appeared to have no effect upon the mitotic response. It is therefore legitimate to pool results from control rats of all groups, and this has been done for the purpose of obtaining a more adequate datum line for the control (untreated) regenerating liver. Rats which had suffered an unusual degree of haemorrhage or shock, or which showed lack of muscular tone or other unfavourable symptoms at the time of irradiation or phosphate injection, were not used.

Results

Mitosis and DNA synthesis in regenerating liver. The rate of synthesis of DNA in the liver of normal rats is low (specific activity of DNA P is 0.5 % of the activity of the inorganic P), but begins to rise between 12 and 15 hours after partial hepatectomy (Holmes and Mee 1954, 1955). The DNA synthesis rate continues to rise until about 24 hours after partial hepatectomy when it may be ten or more times that of the normal liver, but after the onset of active mitosis tends to fall to a lower level. There may, perhaps, be a second smaller peak of high DNA synthesis at 34 to 35 hours, followed by a decline until 46½ hours, and then the rate falls slowly over the next few days to the level found in the resting liver. The period from 20 to 48 hours is shown in Diagram 1. The mitotic activity is indicated by the dotted line.

The synthesis rate of the RNA, whether measured on the whole Schmidt-Thannhauser fraction or on extracted RNA (Barnes and Schoenheimer 1943), rises to about double the normal value a few hours after hepatectomy.

The mitotic activity in normal liver is very low; Brues and Marble (1937) record not more than one mitosis in 10,000 to 20,000 cells. In this investigation, a few mitotic counts have been performed on normal liver, and it is usual to count 200 squares, representing about 5,000 cells, without finding a single mitosis. After partial hepatectomy, a few dividing cells are sometimes found at 22½ hours, and with more regularity at 24 hours; by 25½ to 26 hours, mitosis is frequent, rising to a peak at 27 to 28½ hours. The activity then falls off, with the possibility of second and third smaller peaks at 33 and 45 hours (Diagram 2).

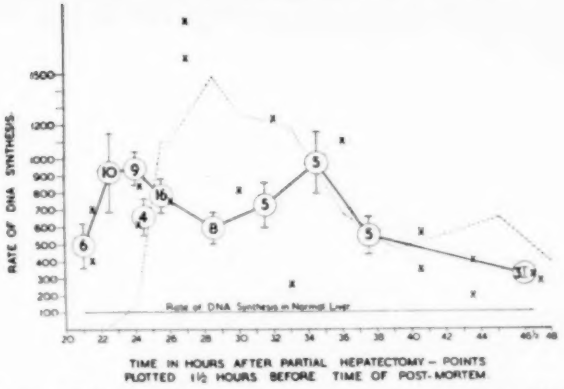
RATE OF DNA SYNTHESIS
Rate of DNA Synthesis in Normal Liver
TIME IN HOURS AFTER PARTIAL HEPATECTOMY – POINTS PLOTTED 1½ HOURS BEFORE TIME OF POST-MORTEM

Diagram 1. Rate of DNA synthesis in liver of control rats after partial hepatectomy; P^{32} given 3 hours before death. The means and standard errors of the means are plotted. Numbers enclosed in circles indicate number of rats; when representing less than three rats, the data from an individual rat is indicated by X. The mitotic activity is indicated by the dotted line.

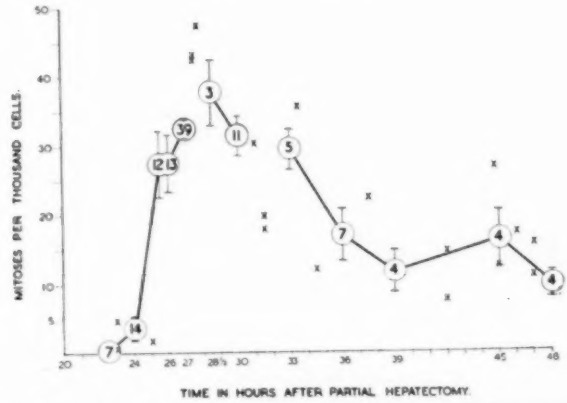

Diagram 2. Mitotic counts after partial hepatectomy. Pooled data from control (untreated) rats.

The data on the number of dividing cells found in each phase of mitosis at various times after partial hepatectomy can be presented in two ways. The absolute numbers of dividing cells in each phase of mitosis are shown in Diagram 3, and the straight percentages in Diagram 4. Comparison of these two diagrams allows certain conclusions to be drawn. The percentage of prophases found is high at 24 hours and falls progressively until about 30 hours, but the actual number of dividing cells in pro-

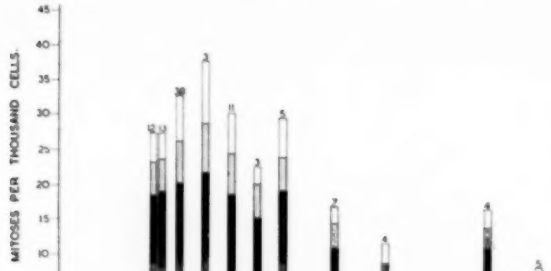

Diagram 3. The number of dividing cells in each phase of mitosis at various times after partial hepatectomy (control rats). From below upwards, prophase cross-hatched, metaphase black, anaphase single-hatched, telophase white. The number of rats is given above each column.

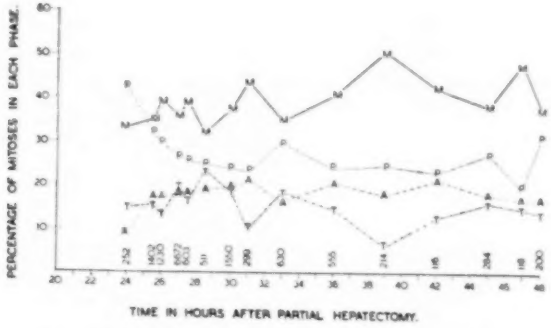

Diagram 4. Percentage of dividing cells in each phase of mitosis at various times after partial hepatectomy (control rats). Prophase P—·—P, metaphase M—M, anaphase A- - -A, telophase T—— — —T. The figures give the total number of mitoses observed at each time.

phase between 25½ and 28½ hours is seen from Diagram 3 to be nearly constant. This would appear to indicate that the number of new cells entering mitosis remains constant during the height of this most active stage of liver regeneration. Diagrams 3 and 4 also support the possibility that there is increased mitotic activity at 33 and 45 hours, as there is both a relative and absolute increase of the frequency of prophases at these times.

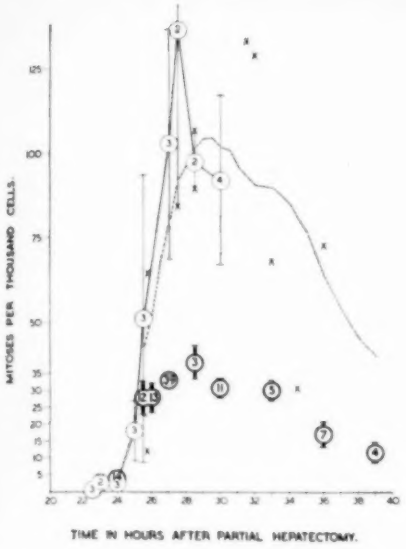

Diagram 5. Mitotic counts when colchicine 0.7 mg/kg was given 3 hours before post-mortem (figures in plain circles) compared with control counts after partial hepatectomy (figures in heavy circles). The expected counts with colchicine, if the time of mitosis is 1 hour, is indicated by the curve – – –.

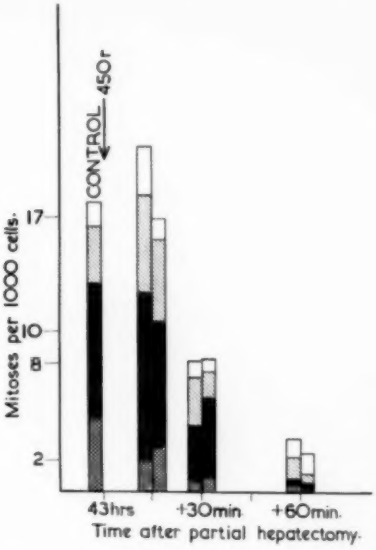

Diagram 6. Decay of mitotic rate after radiation with 450 r of a mixed population of regenerating liver cells at 43 hours after hepatectomy. From bottom upwards; prophase cross-hatched; metaphase black; anaphase single hatched; telophase white. Note the diminution of the prophase count at 15 and 30 minutes after irradiation (cf. diagram 3 at 45 hours). The metaphase count diminishes between 30 and 60 minutes after irradiation. Two experiments shown.

An attempt has been made to find the time taken by a cell to complete mitosis in the regenerating liver *in vivo*. In the first place colchicine was given three hours before post-mortem. Diagram 5 shows the curve of the mitotic index obtained with colchicine compared to the normal curve. It will be seen that colchicine does not cause any summation of the mitotic index up to 25 hours, probably because few cells have reached metaphase before this time. But from $25\frac{1}{2}$ hours onwards colchicine markedly increases the mitotic index. If we assume that mitosis takes 1 hour to complete, and sum the normal curve for each 3 hourly period we obtain the dotted curve, which is a good fit to the colchicine curve. The validity of this method will depend upon the dose of colchicine being sufficient

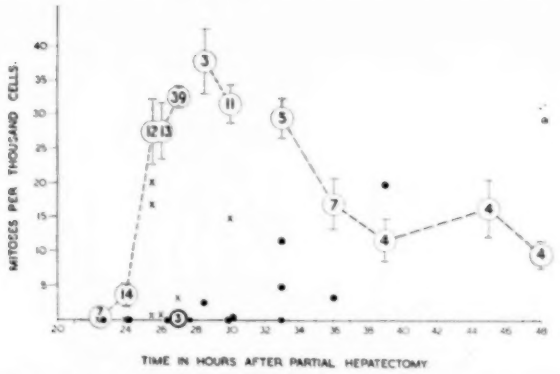

Diagram 7. Effect of radiation at 12 hours after partial hepatectomy upon the number of mitoses per thousand cells, compared with the curve (- - - -) of the mitotic index in the non-irradiated animal. Dose applied: 150 r ×, 450 r • (3), 2,200 r ■. Figures in circles indicate number of animals.

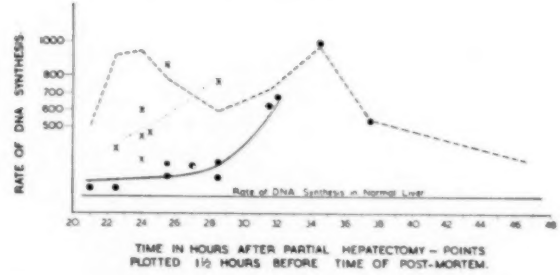
RATE OF DNA SYNTHESIS
Rate of DNA Synthesis in Normal Liver
TIME IN HOURS AFTER PARTIAL HEPATECTOMY – POINTS PLOTTED 1½ HOURS BEFORE TIME OF POST-MORTEM.

Diagram 8. Effect of radiation at 12 hours after partial hepatectomy upon the synthesis of DNA as measured by the incorporation of P^{32}. Dose applied: 150 r . . . . ×, 450 r — •, 2,200 r ■. Rate of DNA synthesis in the non-irradiated controls - - - -.

to arrest mitosis without reducing by its toxicity the entry of cells into mitosis; a condition which is perhaps more easily achieved when the colchicine is in the body for three hours only, than it is in longer experiments. With this qualification the data is consistent with a time for mitosis of about one hour.

Some further evidence on this problem is given in Diagram 6. At 43 hours after partial hepatectomy irradiation with 450 r causes the almost complete disappearance of mitotic figures within 1 hour. The cells in prophase go first, followed by the cells in metaphase, while the cells in telophase are last to go. The validity of this method depends upon certain assumptions; that 450 r stops the entry of cells into mitosis,

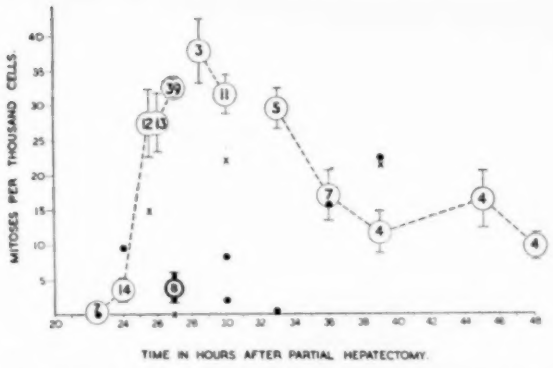

Diagram 9. Effect of radiation at 18 hours after partial hepatectomy upon number of mitoses per thousand cells, compared with the curve of mitotic index in non-irradiated animal. Dose applied: 150 r ×, 450 r • (8). Figures in circles indicate number of animals.

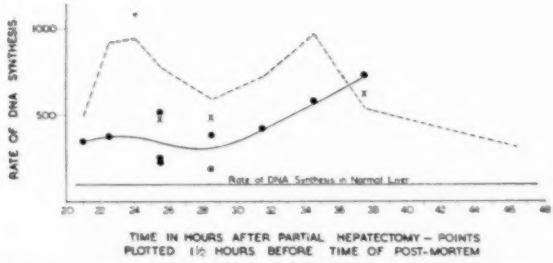
RATE OF DNA SYNTHESIS
Rate of DNA Synthesis in Normal Liver
TIME IN HOURS AFTER PARTIAL HEPATECTOMY – POINTS PLOTTED 1½ HOURS BEFORE TIME OF POST-MORTEM

Diagram 10. Effect of radiation at 18 hours after partial hepatectomy upon the synthesis of DNA as measured by the incorporation of P^{32}. Dose applied: 150 r ×, 450 r —•. Rate of DNA synthesis in the non-irradiated controls – – – –.

without, in the large majority of cases, causing their premature disintegration or delaying the mitotic process unduly by causing stickiness of the chromosomes.

Effect of irradiation on mitosis and DNA synthesis in regenerating liver. The effect of irradiation of liver 12 hours after partial hepatectomy is to delay the onset of mitosis (Diagram 7). With a dose of 150 r the results are somewhat variable, but suggest that the peak of mitosis at 27 hours is diminished. With 450 r, mitosis is absent until 30 hours, is low at 33 hours, and then begins to recover. The irradiation thus delays the onset of mitosis fo.· 9 hours.

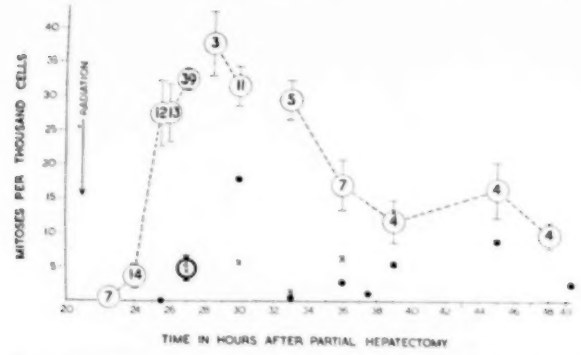

Diagram 11. Effect of radiation at 21 hours after partial hepatectomy upon number of mitoses per thousand cells, compared with the curve of mitotic index in non-irradiated animal. Dose applied: 150 r ×, 450 r ● (4). Figures in circles indicate number of animals.

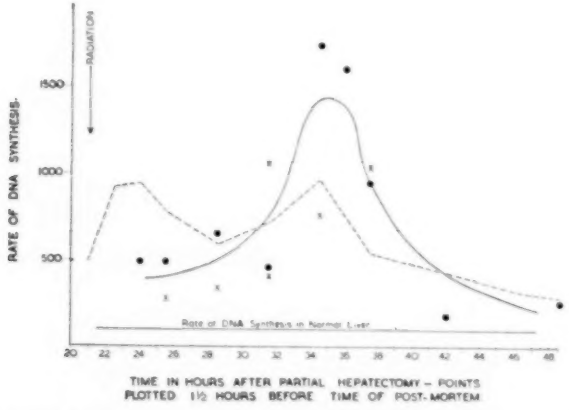
RATE OF DNA SYNTHESIS
RADIATION
Rate of DNA Synthesis in Normal Liver
TIME IN HOURS AFTER PARTIAL HEPATECTOMY – POINTS PLOTTED 1½ HOURS BEFORE TIME OF POST-MORTEM

Diagram 12. Effect of radiation at 21 hours after partial hepatectomy upon the synthesis of DNA as measured by the incorporation of P^{32}. Dose applied: 150 r ×, 450 r —●. Rate of DNA synthesis in the non-irradiated controls - - - -.

The effect upon DNA synthesis is shown in Diagram 8. A dose of 450 r abolished the first peak of DNA synthesis, which remains at little more than the rate in the normal liver until between 29 and 31½ hours. A dose of 150 r delays the rise of DNA synthesis until about 25 hours. The RNA counts are within the normal range, whether measured on the whole SCHMIDT-THANNHAUSER fraction or on the extracted nucleic acids.

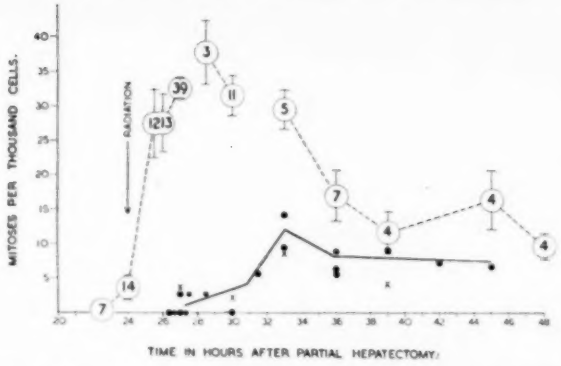

Diagram 13. Effect of radiation at 24 hours after partial hepatectomy upon number of mitoses per thousand cells, compared with the curve of mitotic index in non-irradiated animal. Dose applied: 150 r ×, 450 r —•, 2,200 r ■.

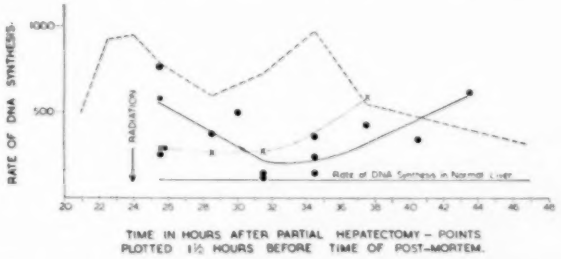
RATE OF DNA SYNTHESIS.
RADIATION
Rate of DNA Synthesis in Normal Liver
TIME IN HOURS AFTER PARTIAL HEPATECTOMY – POINTS PLOTTED 1½ HOURS BEFORE TIME OF POST-MORTEM.

Diagram 14. Effect of radiation at 24 hours after partial hepatectomy upon the synthesis of DNA as measured by the incorporation of P^{32}. Dose applied: 150 r . . . ×, 450 r —•, 2,200 r ■. Rate of DNA synthesis in the non-irradiated controls – – – –.

Radiation with 450 r at 18 hours after partial hepatectomy reduces mitotic activity to low levels. Recovery takes place between 33 and 36 hours (Diagram 9). There is some reduction of mitosis after 150 r.

The DNA synthesis tends to be low after radiation with 450 r given 18 hours after partial hepatectomy (Diagram 10). The depression of synthesis is not at first as great as that caused by irradiation at 12 hours, but is marked at 27 hours after operation. There is a slow recovery from 32 hours onwards. The scanty data available suggest that a dose of 150 r has no significant effect on DNA synthesis. The RNA counts are somewhat variable but tend to be high at $37\frac{1}{2}$ hours.

Radiation at 21 hours after hepatectomy (just before the onset of cell division) has a marked effect in depressing mitosis (Diagram 11) but has a less drastic effect upon the first peak of DNA synthesis (Diagram

12). The evidence available suggests an increase of the second peak of DNA synthesis. High figures were also found for RNA at this same time.

Radiation at 24 hours, just as mitosis is beginning, abolishes the first wave of mitosis (Diagram 13) but there is some recovery at 33 hours, corresponding to the second wave of mitosis, that is within 9 hours of the radiation. The effect of 150 r appears similar to that of 450 r.

The second peak of DNA synthesis appears to be delayed by 150 r or 450 r at 24 hours after partial hepatectomy (Diagram 14). The lowest values are found in animals killed between 9 and 12 hours after irradiation. The RNA synthesis appears to be unaffected.

Discussion

Some difficulty was experienced in deciding how best to synchronise the mitotic counts with the DNA synthesis as indicated by the P^{32} uptake over the previous 3 hours. It is known that P^{32} is rapidly absorbed, and that its entry into the DNA fraction is not long delayed (HEVESY 1945). In a dynamic system, which is undergoing changes in the rate of activity, it is impossible to calculate the exact point during the 3 hour period at which the DNA synthesis equals the P^{32} counts in the DNA extracted at post-mortem. However, it appears more legitimate to relate the DNA synthesis to the mid point of the 3 hour period than to the end, and this has been done.

High protein feeding before operation was instituted in case the animals were in any sense protein deficient. Careful scrutiny of the results for rats which were supplemented compared with those which were not, reveals no tendency to earlier or higher mitotic counts. The figures available for DNA synthesis are too few to show any trend. Since protein pre-feeding was instituted most of the DNA fractions have been obtained by the saline extraction method of BARNES and SCHOENHEIMER and may not be exactly comparable with the earlier results. The impression gained is that protein pre-feeding gives rather more consistent results. It may increase the first high peak of DNA synthesis and possibly reduces the second peak.

There can be no doubt about the first peak of mitosis beginning at 24 to 25½ hours after partial hepatectomy and reaching its maximum at 27 to 28½ hours; but the evidence for a second and third peak at 33 and 45 hours is much less substantial. This period after partial hepatectomy has not been so fully investigated, but the indications from the mitotic counts and the increase of the prophase count is suggestive.

The time taken for the mitosis of fibroblasts in tissue culture has been measured by SIMON-REUSS and SPEAR (1947), but as far as the authors are aware no figures are available for rat liver *in vivo*. The colchicine counts were made partly with this object in view, but also to relate DNA synthesis with the total mitotic activity of the comparable three hour period.

It is noteworthy that the rate of DNA synthesis falls when the rate of mitosis has reached a high level. This must depend upon the timing of the events in the mitotic cycle, using this term in the sense defined by HUGHES (1952) to include DNA synthesis, a possible pause (see HOWARD and PELC 1952), mitosis, reconstruction, and a resting period.

There are other changes taking place in regenerating liver which deserve comment. The cell size increases, and some indication of this is obtained from the number of nuclei found in 200 squares. In the normal liver this is about 5,000, but falls to about 4,000 in regenerating liver. The size of the nuclei increases. The size of 200 nuclei was measured in a sample of 39 cases from the experimental material. The average nuclear volume was calculated by the formula

$$0.5236 \frac{(\Sigma\ d_1^3 + d_2^3 + \ldots\ldots\ldots d_{200}^3)}{200}$$

In regenerating liver, the average nuclear volume was about double that of normal liver, but no consistent relationships were found in this sample between nuclear size and time after hepatectomy or radiation. It was felt that the information yielded by this tedious method of investigation did not justify the labour involved.

A dose of 450 r of 220 kV_p roentgen radiation at 12 hours after partial hepatectomy abolishes the first peak of DNA synthesis and the first and second waves of mitosis. Radiation at 18 hours has a similar but at first less marked effect upon the DNA synthesis and mitosis. Radiation at 21 hours has only a small effect upon the first peak of DNA synthesis, but the data available suggest an accentuation of the second peak of DNA synthesis; the P^{32} uptake into RNA is also high. This effect requires further investigation, and, if real, is capable of more than one explanation. It is tempting to suggest that it is due to inhibition of mitosis.

The DNA required for the first peak of mitosis is already made by 24 hours; yet radiation with 150 r or 450 r is sufficient to abolish completely the very active first wave of mitosis. This effect cannot be explained in terms of altered DNA synthesis. An explanation might be sought in the inhibition by radiation of some other process in the mitotic cycle.

Added in the proofs

The standard errors of the means have been shown on the diagrams 10 to 20 per cent larger than they should have been drawn. The results are in fact better than as shown, especially where the number of rats was 3, 4 or 5. For instance, the results with colchicine in Diagram 5 should be shown with considerable less scatter. However, the character of the results and their interpretation is in no way affected.

Acknowledgements

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SUMMARY

The relationship between mitosis and DNA synthesis in the early stages of liver regeneration in rats has been investigated. At 27 hours after partial hepatectomy a high rate of mitosis is found. This is preceded by a rapid rate of uptake of P^{32} into DNA. The duration of mitosis, as indicated by counts after colchicine, and also after small doses of roentgen rays, appears to be about one hour. Small doses of roentgen rays given during the early stages of regeneration show an immediate effect in arresting mitosis but only a delayed effect on DNA synthesis.

ZUSAMMENFASSUNG

Die Beziehungen zwischen Mitose und DNA-Synthese ist in Frühstadien der Leberregeneration bei Ratten untersucht worden. 27 Stunden nach partieller Hepatectomie wurde eine grosse Anzahl von Mitosen gefunden. Diesem geht eine sehr schnell vorsichgehende Aufnahme von P^{32} in der DNA voraus. Die Dauer der Mitose scheint, nach den Ausschlägen nach Colchicin sowie auch nach kleinen Röntgendosen zu urteilen, etwa eine Stunde zu sein. Kleine Röntgendosen, die während der Frühstadien der Regeneration gegeben werden, zeigen einen unmittelbaren die Mitose einhaltenden Effekt, jedoch nur einen allmählich verzögernden Effekt auf die DNA-Synthese.

RÉSUMÉ

Les recherches des auteurs ont porté sur les relations entre les mitoses et la synthèse de l'ADN dans les premiers stades de la régénération du foie chez le rat. Vingt-sept heures après hépatectomie partielle, on trouve une forte proportion de mitoses. Ceci est précédé par une rapide fixation de P^{32} dans l'ADN. La durée des mitoses, mesurée par des numérations après colchicine, et aussi après de petites doses de rayons roentgen, paraît être d'environ une heure. Les petites doses de rayons roentgen administrées pendant les premiers stades de la régénération agissent immédiatement en arrêtant la mitose, mais n'ont qu'un effet retardé sur la synthèse de l'ADN.

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FROM KING GUSTAF V. JUBILEE CLINIC (DIRECTOR: PROF. MAGNUS STRANDQVIST)
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THE TECHNIQUE OF TREATING THE PITUITARY GLAND WITH ROENTGEN ACCORDING TO THE PENDULUM PRINCIPLE

by

Bengt H. O. Rosengren

Roentgen treatment of the pituitary gland may be used for treating pituitary tumours and hyperfunctional conditions *e. g.* in Cushing's disease, acromegaly, and exophthalmus in exophthalmic goiter. In 1909, GRAMEGNA described a technique for this treatment; the irradiation was administered transorally. In 1913, BÉCLÈRE also published a paper in which he described the application of the rays via the temporal areas and the forehead on a skin field 3 cm in diameter; the skin dose was equivalent to about 150 r on each field. Later on this therapy was gradually tried at several clinics. In 1935, BOARK discussed this treatment in thyrotoxicosis and certain gynecologic diseases.

Depending on the disease to be treated, depth doses of 3,000 to 5,000 r are now given to attain the desired therapeutic effect. The technique generally used is as follows. The pituitary gland is radiated from two or several fixed skin fields, *i. e.* from both temporal areas, from the forehead, or possibly from below both orbits. The distance to the pituitary gland is about 7 to 8 cm, 60 to 70 % of the irradiation at the usual 150 to 200 kV is absorbed and only 30 to 40 % will reach the destination. If, for example, a depth dose of 5,000 r is required in the pituitary area, four skin fields, approximately 3,600 r each, must be given; this dosage will cause irritation of the skin, such as dry epidermitis and more or less permanent pigmentation, epilation, and possibly as a sequence, telangiectatic formations and atrophy of the skin.

It is possible, however, to reduce and even completely eliminate these disturbing skin reactions by extending the skin dose over a larger

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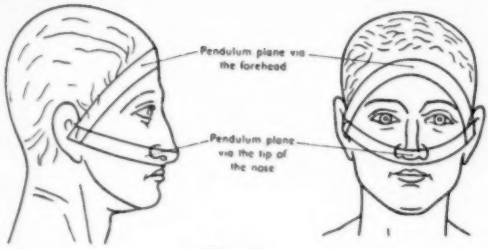

Fig. 1.

area by means of rotational or pendulum irradiation. If required, considerably greater doses can then be given without any risk of an overdose. An intermediary method is that described by LOW BEER et coll., by means of which up to eight small fields of 2.8 cm in diameter may be radiated. DESSAUER et coll. were the first to describe the rotational treatment of the pituitary gland, performed on an acromegalic patient in 1937.

One of the difficulties in rotational therapy is to determine the exact depth dosage. It is especially difficult to estimate the dose within the complicated anatomy of the cranium. To measure the dose direct by placing ionization chambers in the pituitary region is quite impossible and phantoms, as natural as possible, must be constructed. In 1937, DESSAUER et coll. constructed a phantom of the head around a skull of bone in which the soft parts were replaced by cardboard. The rate of the dose was then found to increase by 15 % in the pituitary region of the phantom, excluding the skull of bone. GEDDA and LINDGREN used a phantom built by CEDERLUND, in which the soft parts were replaced by wax. By irradiating four fixed temporal fields, 5 × 6 cm in size, 45 % of the skin dose per field reached the pituitary region. At the Radiotherapeutic Clinic, Gothenburg, a suitable phantom has been constructed by BENNER and TURESSON. The soft parts in this are replaced by a substance called 'Mixed D', which is a tissue equally susceptible to roentgen rays. This substance has been worked out by JONES and RAINE. The phantom is sectioned approximately 5 cm above the pituitary plane and ionization chambers are inserted in holes drilled in suitable places.

In roentgen treatment the hairy parts of the head are often spared owing to the risk of epilation, the facial region consequently being the only one left available. This area, however, is also limited as the eyes tolerate but slight irradiation and are susceptible to roentgen cataract. The patient usually wears eye-protectors of lead during the irradiation. The mandibular region is less favourable as the distance to the pituitary region is greater, resulting in an increased loss due to absorption. The temporal regions, the forehead and the facial area between the mouth and eyes remain. Thus, two different planes can be used for pendulum irradiation; one is defined by three points *viz.* the centre of the forehead and the pituitary point of projection of each temporal region; the other

by the two latter points and the tip of the nose. The latter plane has been suggested by STRANDQVIST, as a reduced loss of absorption can be expected because of the radiation largely being transmitted through the air-filled cavities of the jaw and nose (Fig. 1).

In order to plot the dosage of pendulum irradiation used in the vicinity of the pituitary gland, the above-described skull phantom was irradiated with Müller's pendulum apparatus TU I with the factors: 200 kV, 18 mA, filter: 0.2 mm Cu, tumour—focus distance 50 cm, angle of the pendulum 210°, and a tissular factor estimated at 1.0. These values have been found to be appropriate from the clinical point of view, inter alia, because by using a field of this size time-consuming adjustments need not be accurate. The calculated dose has been 250 r according to Wickmann's tables of dosage for this apparatus. The ionization chambers were placed in the drilled holes as shown in Fig. 2. The holes reach the base of the skull and hole No. 7 penetrates the sella turcica.

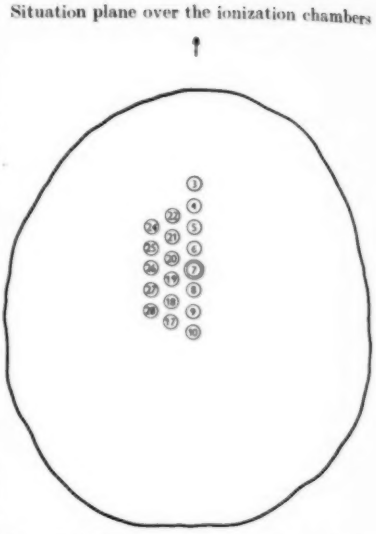

Fig. 2. Plane over the ionization chambers. No. 7 is placed in sella turcica.

At first, five irradiations were performed in the two pendulum planes (via the tip of the nose and the centre of the forehead, respectively) and were centered according to Wickmann's tables, 1 cm *below* the estimated maximum dose, *i. e.* 1 cm below pituitary chamber No. 7. The calculated mean values of each series are seen in Figs. 3 and 5.

Centration in different points was then attempted in order to find out the most uniform dispersion of the irradiation dose around the hypophysis. The best dispersion was obtained in the two rotational planes if the actual pituitary chamber was centered (See Figs. 4 and 6 with mean values after 7 and 5 irradiations, respectively).

By comparing the results of the four series of irradiation the following conclusions may be made:

1. By pendulum irradiation over the face through the tip of the nose, in the pituitary chamber, a mean value of 285 r was obtained at a centre 1 cm below, and 286 r at a centre inside the actual chamber. The corresponding values by pendulum irradiation via the forehead are 208 r and 208 r, respectively, *i. e.* the dose being reduced by 28 %. The air content in the sinuses may cause the increased transmission, which is

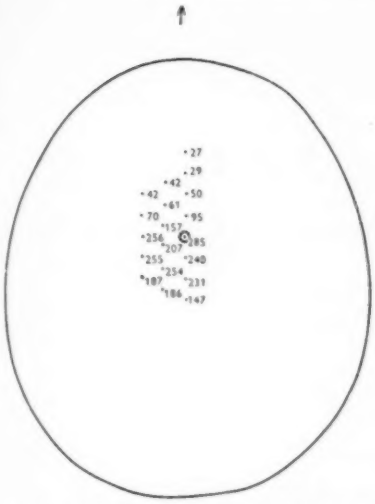

Fig. 3. Pendulum plane: via the tip of the nose. Pendulum centre: 1 cm below the pituitary gland.

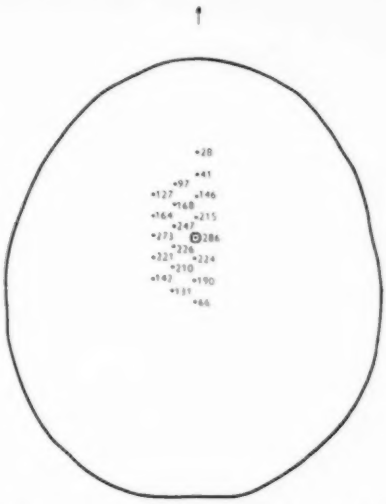

Fig. 4. Pendulum plane: via the tip of the nose. Pendulum centre: in the pituitary gland.

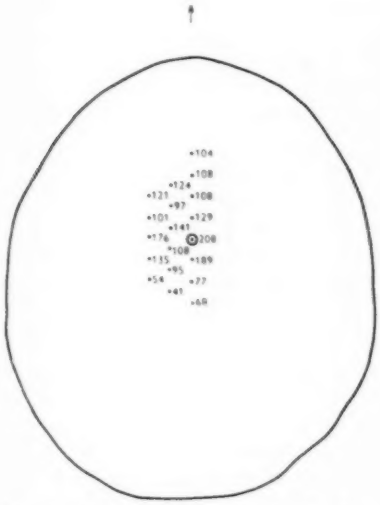

Fig. 5. Pendulum plane: via the forehead. Pendulum centre: 1 cm below the pituitary gland.

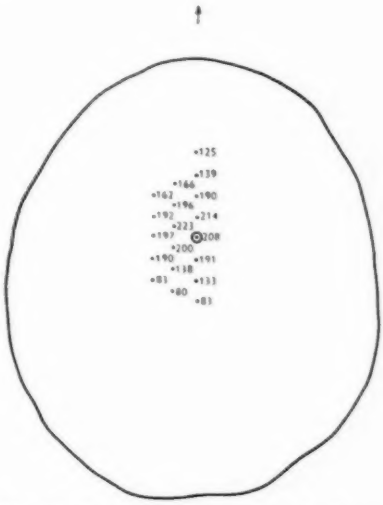

Fig. 6. Pendulum plane: via the forehead. Pendulum centre: in the pituitary gland.

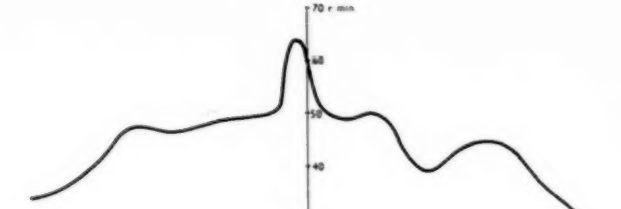

Diagram 1.

also seen in Diagram 1, where by means of a dosimeter the rate of transmission in the sella turcica is indicated directly at different angles during the pendulation. The values rise with the air content in the sinuses and culminate on the medium line, despite this distance from the hypophysis to the skin being the greatest, *viz.* 8 cm compared with 7 cm, the straight lateral measurement. A planimetrified curve will result in an integrated dose of 45.2 r/min. Using the same time of irradiation as for measuring condensation chambers, *viz.* 6.4 min, the dose will be 289 r, which tallies well.

2. At the recommended centration of 1 cm below the pituitary chamber in both rotational planes, the ionization chambers placed in front of the pituitary chamber show very much lower values than those placed behind at an equivalent distance. The latter chambers are placed 1 to 1.5 cm lower than the front ones, but remain all the time within the rotational field. However, when the rays are centred in the middle of the pituitary chamber, *i. e.* in the sella turcica, the dispersion of the dose is more uniform and appropriate. There are probably several reasons contributing to these observations; quite an important cause may be that the areas in front of and below the pituitary body to a great extent consist of cavities filled with air, while the areas behind and above consist of homogeneous brain substance. The difference in absorption may result in the secondary radiation from the front and below being less than that expected from above and behind, and as a sequel the dose maximum may, inter alia, be displaced backwards. This has been studied closely in the phantom by irradiating a field, measuring 17 × 24 mm, from the temporal region and placed at 5 mm to the front of the sella

turcica, during the course of which the secondary radiation upon it was measured. The experiment was then repeated, the field being moved towards the back of the head 5 mm behind the sella turcica. The measured secondary radiation with the field to the front of the sella turcica was 65 % of that obtained when the field was behind. The same result was attained by irradiation from both temporal regions.

With pendulum irradiation in the planes through the forehead and the tip of the nose, the integrated eye dose (with protectors of lead) was 8.5 % and 11 %, respectively, of the depth dose in the pituitary region. GEDDA and LINDGREN state that, when irradiating from fixed temporal fields, the corresponding value is 37 %. Pendulum irradiation according to the above technique is therefore to be preferred to irradiation of fixed fields.

In practice, pendulum irradiation of the hypophysis has been performed at the Radiotherapeutic Clinic, Gothenburg, under the above-mentioned conditions and with a depth dose of 200 r or 250 r per treatment. When the depth dose amounted to 3,250 r, the skin dose was about 1,000 r, the ratio being 3.2 : 1. As a rule the pendulum therapy was commenced in the plane through the tip of the nose resulting in an output of up to approximately 3,000 r reaching the pituitary region, and continuing through the forehead if larger doses were considered necessary. Eye-protectors of lead have always been used.

The advantages of pendulum irradiation instead of treatment with fixed fields against the pituitary gland are, inter alia, as follows.

Irradiation up to a facial skin dose disturbing from the aesthetic point of view, may almost be completely avoided even with large depth doses. Adjustments of the apparatus need not be performed. Only a small field of treatment is used; this is clinically important as damage to the surrounding healthy tissue will be reduced. When treating exophthalmus in Basedow's disease it is easier to determine whether regression of the eye symptoms depends on irradiating the hypophysis only, or if this is due to the orbital tissue also being affected.

With sedentary rotation the roentgen tube is fixed and the patient is placed in a rotating chair. When the pituitary gland is to be treated, the patient sits with his head bent slightly forward. The beam of roentgen rays circles around the capillitium. If the surface of the field is small enough epilation will be avoided even at large depth doses. The small field, however, requires thorough fluoroscopic control during the treatment. This difficulty may be overcome with pendulum irradiation of the forehead and the face by using slightly larger fields according to the technique described above. The irradiation in the plane through the tip of the nose should not be exaggerated, however, as slight rhinitis or sinuitis often develops.

The measurements of the phantom described above indicate that the dose rate in the pituitary region with pendulum irradiation is 35 % greater in the plane through the tip of the nose than in the plane through the forehead. From the measurements it is also seen that 1.14 is an expedient tissue factor with pendulum irradiation in the first-mentioned plane, and 0.82 in the latter plane when determining doses according to Wickmann's tables for Müller TU I. Finally, the dispersion of dose in the pituitary region is most favourable in both cases when the centration is made in the actual pituitary gland. Practically, however, it is more convenient to center a few mm below the sella turcica depending on that the depth dose decreases rapidly in direction from the pendulum arc.

SUMMARY

In order to plot the dosage of pendulum irradiation used in the vicinity of the pituitary gland, a skull phantom containing ionization chambers was irradiated with Müller's pendulum apparatus TU I. Two pendulum planes were used: Over the tip of the nose and over the forehead. The measurements indicate that irradiation over the first-mentioned plane gives 35 % better transmission than over the latter. The dispersion of the dose was best when the pendulum centre was in the pituitary gland.

ZUSAMMENFASSUNG

Zur Festlegung der Dosis bei Pendelbestrahlung in der Nähe der Hypophyse wurde ein Ionisationskammern enthaltendes Schädelphantom mit Müller's Pendelapparat TU I untersucht. Zwei Pendelbahnen wurden benutzt, nämlich eine über die Nasenspitze und die andere über den Vorderschädel. Die Messungen ergaben, dass Bestrahlung über die erstere Ebene 35 % bessere Transmission ergibt als über die letztere. Die Gewebefaktoren betragen 1.14 bezw. 0.82. Die Dispersion der Dosis war am günstigsten, wenn das Pendelzentrum in der Hypophyse lag.

RÉSUMÉ

Pour déterminer la répartition des doses en radiothérapie pendulaire utilisée dans la région hypophysaire, l'auteur a irradié un fantôme de crâne contenant des chambres d'ionisation avec l'appareil TU I de thérapie pendulaire de Müller. Il s'est servi de deux plans d'oscillation: sur le bout du nez et sur le front. Les mesures montrent que l'irradiation dans le premier de ces plans donne une transmission de 35 % meilleure que dans le deuxiéme. Les facteurs de transmission en profondeur convenables sont respectivement 1.14 et 0.82. La dispersion de la dose est la meilleure quand le centre d'oscillation est dans l'hypophyse.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. K. LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

A DOUBLE-MIRROR FOR VIEWING STEREOSCOPIC ROENTGENOGRAMS

by

Ove Mattsson

An increased interest in stereoscopic roentgenography is apparent, and a special two-tube roentgen apparatus with a rapid film changer enabling the production of practically simultaneous stereo-pairs in angiography, as described by FERNSTRÖM and LINDBLOM (1955), has been introduced. Other equipment facilitating stereo-roentgenography has also been designed recently, such as couches permitting a rapid change in positioning of the patient and suitable for single-tube stereo-roentgenography (SJÖGREN 1956). The blood vessels form ideal objects for stereoscopic examination, and it is to be expected that stereo-angiography will further increase the diagnostic possibilities of the procedure. In the writer's opinion, the methods of viewing stereo-roentgenograms are not wholly satisfactory; a contribution to the solution of the problem is now presented.

The requirements in a stereoscopic viewer for roentgenographic purposes are exceptional; film sizes may vary from small ones for dental views up to large ones for chest or abdominal views. The well-known principle of BREWSTER's stereoscope of 1852 is not suitable for roentgenograms, as its use is limited to moderate film sizes. Complicated systems containing prisms and lenses have been used, especially in photogrammetric studies of films (HASSELWANDER). HADLEY (1930) as well as CALDWELL (1918) discussed the use of fairly simple designs with prisms in special mounts; the former improved a construction developed by the latter in 1906. LYSHOLM (1926) devised a magnifying stereoscope consisting of Zeiss prism binoculars fitted with additional lenses.

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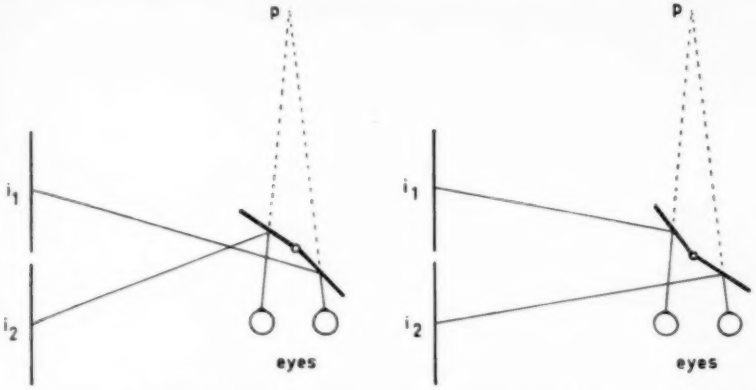

Fig. 1. Passage of rays in viewing stereoscopic roentgenograms with the double-mirror. Either crossed (a) or uncrossed (b) passage of rays is possible; i_1 and i_2 are corresponding points in the films, p is the virtual image.

WATSON (1941) described a monocular prismatic stereoscope employing the well-known principle of a single mirror, in which one film is viewed by reflection while the other is seen directly. WATSON used a monocular prism to avoid double contours of mirrors. KEREKES (1956) described a simple stereoscope with a single front-surfaced mirror, used in the same manner as WATSON's prism. The incorporation of front-surfaced mirrors, however, is not to be recommended since, according to WATSON, their surface is easily destroyed. With systems using only one mirror or prism it is necessary that one of the films be turned left to right, which is impossible in the case of angiographic stereograms on roll film. In 1949, GASS and HATCHETT described a set of prisms to be used like eyeglasses. In addition to the devices described, viewers of various makes, including prisms and fairly expensive optical components, are marketed.

Against the background of previous constructions the writer intended to make a simple and cheap stereo-viewer which would be easy to handle and function well, especially from a physiologic point of view. Many people find stereoscopic viewing difficult, often because of the imperfect function of such stereo-viewers which require unphysiologic adjustment of the eye axes in relation to the lens accommodation.

The mirrors are joined by means of a hinge. The films, placed side by side in front of a viewing lantern, are studied via the mirrors in accordance with the schematic drawing shown in Fig. 1. Either a crossed or uncrossed passage of rays is possible. Large films are viewed at a distance, smaller ones closer. The mirrors may readily be adjusted so

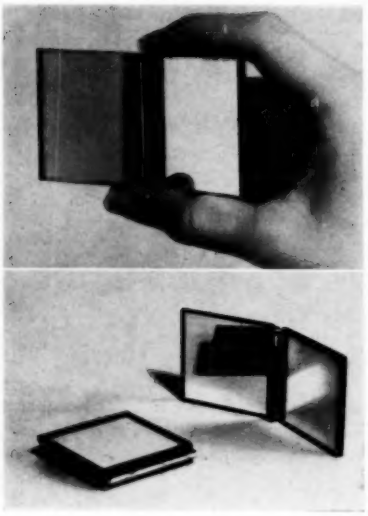

Fig. 2. Double-mirror for stereoscopic viewing, preferably to be held in the right hand.

that the degree of convergence of the eyes is comfortable. The continuous lines connect corresponding points of the films, i_1 and i_2, with the eyes; the dotted lines represent the passage of rays from the virtual image at p. By individual adjustment of the angle between the mirrors, all those able to use binocular vision may enjoy comfortable stereoscopic viewing. Tests of a group of individuals have shown that many who could never use ordinary stereoscopes, readily accepted this simple arrangement.

The appearance of the double-mirror is shown in Fig. 2. The device is preferably held in the right hand, the viewing box being to the left of the observer. When not in use, the mirrors may be folded; their surfaces are protected (bottom left in the figure).

Since the eyes are not directed towards the source of light — the viewing box — they will not be much disturbed by it. It is, however, preferable to screen off all unnecessary light in the room, since this might unfavourably influence the interpretation of the contrast in the film (MATTSSON 1952). The mirrors give less disturbing light phenomena than any other optical system for stereoscopy tested by the writer. Front-surfaced mirrors have been tried but found to be unnecessary. Reflexion from the glass surfaces is of minor importance for the angles of reflection with which we are concerned. The quality of the mirrors is of great importance and thin glass should preferably be used.

The double-mirror described produces in the simplest way a satisfactory result in the stereoscopic viewing of roentgenograms. It is easily adjusted individually for any optical need; it is ot pocket-size, light and handy.

SUMMARY

The writer describes a double-mirror for viewing stereo-roentgenograms.

ZUSAMMENFASSUNG

Ein Doppelspiegel, der zur Betrachtung von Stereo-Röntgenbildern geeignet ist, wird beschrieben.

RÉSUMÉ

L'auteur décrit un miroir double pour examiner les stéréoradiographies.

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RADIATION DOSES TO PATIENTS AND PERSONNEL IN MODERN ROENTGEN DIAGNOSTIC WORK

by

Lars-Eric Larsson

During the past few years, development of roentgen diagnostics has been rapid. New and more extensive examinations have been adopted for clinical use, and the annual number of examinations has considerably increased. This development has, however, been associated with an increased risk for patients and personnel of being exposed to excessively large radiation doses. The object of the present investigation was to obtain a conception of radiation doses in modern roentgen diagnostic work.

It must nevertheless be stressed that the dose values given below only illustrate those to which patients and personnel can be exposed. The same examination may be performed with a different technique in other diagnostic departments. But even under identical conditions, considerable dose differences arise.

Table 1

Dose rates to patients in fluoroscopy with different undercoach tubes

kV	mA	Visible added filter, mm Al	Focus—skin distance, cm	r/min
80	3	1	60	1.1
80	3	0	60	5.5
80	3	0	60	8.0
70	2	0	60	4.0
95	1	0	60	3.3
95	2.5	0	60	9.0
68	3	0	45	14.3 (8.0)[1]

[1] Converted to focus—skin distance 60 cm

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Table 1 shows, under actual conditions, the radiation doses per minute to the patient during fluoroscopy with different undercoach tubes. The dose values vary considerably although in some cases the working data coincide, and even if the data differ, the great variations in dose cannot always be explained by this fact alone. The reason must be sought among the following factors:

1. Errors in kV and mA meters;
2. Different tube filters;
3. Difference in shape of the wave-form of the output voltage;
4. Variation in the power of absorption of the mattress on which the patient lies: in the course of measurements, mattresses were found which absorbed about 50 per cent of the radiation.

Consequently, considerably faulty estimations can be made if standard curves alone are used for calculation of the doses to which the patients are exposed. It therefore seems important for the roentgen diagnostic tubes to be measured in such a way that the radiologists know the dose rates, in any event for fluoroscopy. During clinical measurements, unexpected changes in the dose rates occurred, but the reason could not be ascertained. It can therefore be questioned whether the dose rates should not be checked at intervals.

Radiation doses to patients

The object of these measurements was not to state the exact magnitude of the radiation doses to which the patients are exposed in different examinations, but to show that in some investigations the doses are fairly high and comparable to those given in radiotherapy, whereas in others they are very small. As far as possible, the measurements were made during actual examinations. During roentgenography, the doses were in some cases measured on a tissue-equivalent phantom, Mix D (5). Otherwise, the chambers would have disturbed the results of the examination by being reproduced in the films.

Different types of ionization chambers were used:

(a) between 10 r and 200 r, condenser chambers, type Bg, according to SIEVERT (6)
(b) » 4 » » 25 », Victoreen chamber
(c) » 1 » » 4 », condenser chambers constructed by VIKTERLÖF (unpublished).

In the range of high tension used, between 50 kV and 150 kV, the chambers had sufficiently good independence of energy for this kind of measurement. They were attached to the patients and the phantom by special adhesive plaster containing only low-atomic materials. The cham-

bers (a) were specially suitable for measurements during fluoroscopy. Placed on the patients, they did not produce any disturbing images on the fluorescent screen.

In measurements on the phantom, the exposures giving small dose values were repeated if required by the dose range of the type of chambers used.

Cardiac catheterization and angiocardiography. Condenser chambers (a) were placed on the back of the patients in such a way that the beam would fall on them. Two or three pairs of chambers were placed about 5 cm apart. The highest mean values from these pairs were used. Table 2 shows the distribution of these values from 32 cardiac catheterizations in 7 hospitals. The largest measured dose value was 206 r.

Table 2

Distribution of patient doses from 32 cardiac catheterizations in 7 hospitals

	Doses in r				
	<25	25—49	50—74	75—99	≥ 100
No. of cardiac catheterizations	12	8	4	4	4

The true fluoroscopic time was measured with a chronometer. It ranged from 5 to 36 minutes. The lowest dose rate was 1 r/min and the highest 8 r/min.

The measured dose values were compared to the values calculated by multiplying the true fluoroscopic time in minutes by the dose rate in r/min at the focus—skin distances used, and were found to be less than the calculated values. The differences depend on the fact that the radiation field is moved during fluoroscopy. Statistical analysis of the results gives a simple rule for estimating the actual dose at cardiac catheterization. The patient dose is 75 ± 20 per cent of the dose calculated as above.

In angiocardiography with a biplane film changer (simultaneous exposures in two directions) using 110 kV, 10 mAs/exp., focus—film distance 95 cm and with no added Al filter, the radiation dose to the patient was found to be 0.25 r/exp. These conditions apply to a robust patient. Usually, the radiation fields for the a. p. and the lateral projection do not overlap. Consequently, in angiocardiography with the data given above and with 60 exposures in each plane, the patient receives 15 r.

In catheterization with subsequent angiocardiography, the patient usually receives the largest dose during fluoroscopy. It may be pointed out that the fluoroscopic field does not coincide with the fields of angiocardiography.

Colon and stomach examinations. The usual way of indicating radiation doses, *e. g.* the largest dose on one and the same radiation field, does not seem to give an adequate expression of the radiation dose to the patient. For example, in these examinations the radiation field is perpetually moved, as a result of the patient being turned in different positions. Moreover the size of the radiation field varies considerably. In order to ascertain the amount of radiation received by the patient in these examinations, it seems necessary to use volume-dose calculations. Unfortunately, phantoms cannot be used for the measurements, since the real course of these roentgen examinations depends on such factors as the movements of the contrast medium, the behaviour of the patient and the position of the object to be examined.

It may nevertheless be stated that the exposures during colon and stomach examinations contribute only slightly to the radiation doses to the patient. During these exposures with the undercoach tube and a high voltage technique, a patient dose of 0.3 r/exp. was measured. The data were 140 kV, 12 mAs, focus—film distance 60 cm and no added Al filter. During fluoroscopy, on the other hand, the dose per minute, taken from Table 1, is 4 to 8 r.

Bronchography. The radiation doses to the patients were measured with the technique used at cardiac catheterization. The largest dose value, 100 r, was measured at bronchography with fluoroscopy for 7.6 min at 60—70 kV, 3 mA, focus—skin distance 45 cm and with no added Al filter.

As a rule, the examinations combined with fluoroscopy give the largest doses to the patient. Although most of the exposures imply moderate doses, there are exceptions, *e. g.* roentgenography of the lumbar spine.

Lumbar spine. In the a. p. projection, with the usual data 60 kV, 520 mAs, focus—film distance 100 cm and no added Al filter, the measured patient dose was 6 r. In the corresponding lateral projection with 90 kV and the remaining data unchanged, the dose was 22 r. This large difference did not only depend upon the tube potential being increased by 30 kV. The focus—skin distance was 73 cm in the a. p. projection but only 59 cm in the lateral.

Planigraphy (tomography). This technique involves the exposures being repeated several times. Taking into consideration that the focus-skin distance decreases for every adjusted layer, the calculated total radiation doses at tomography of lumbar spine, with 10 exposures and with the data given above, were 65 r for the a. p. projection and 240 r for the lateral.

The possibility described by BACKLUND (2) of making all exposures simultaneously will be of great importance in reducing the radiation doses.

Measurements together with Backlund showed that in simultaneous planigraphy of the lumbar spine (lateral view) the dose to the patient need be only 2 r. This is only 1 per cent of the dose mentioned above. The data for this exposure were 120 kV, 550 mAs, focus—skin distance 110 to 122 cm and 3 mm added Al filter.

Comments. In modern roentgen diagnostics, the patient occasionally receives radiation doses which are comparable in magnitude to those given in radiotherapy. Consequently, it seems to be necessary for the radiologists in diagnostic departments to be able to calculate the doses to the patients. This view has also been expressed by ARCHER (1) and by JACOBSON, SCHWARTZMAN and HEISER (4). As already mentioned, the dose rates during fluoroscopy must be individually measured. Moreover, objective possibilities must exist of recording the true fluoroscopic time, suitably with a watch coupled in such a way that it automatically runs only when fluoroscopy is actually being performed. The radiologist can then in most cases decide whether, in view of the radiation hazards to the patient, he must speed up the examination. Patient doses above 50 r should be noted on the case record. At present an increase in the filtering of the useful beam is being introduced. This increase is an effective and simple means of reducing the doses. If the total filter at 100 kV is increased from 1 to 3 mm Al, the doses will be reduced by about half.

Radiation doses to the personnel

When measuring the radiation doses to which the personnel is exposed in radiologic work, the usual procedure is to use ionization chambers or film badges placed, as a rule, on the chest. Using double chambers designed by SIEVERT and WALSTAM (7), measurements were made in this way during routine work, particularly in the roentgen diagnostic departments at Karolinska Sjukhuset, Stockholm. The double chambers were placed both on the chest and in one of the hip-pockets. They were worn for one week and then exchanged for new ones. The distribution of the dose values is shown in Table 3. It is seen that none of the 194 double measurements gave a dose value exceeding 300 mr/week. Only 3 values were above 100 mr/week. The results agree with many similar measurements that have been published.

Table 3

Distribution of measured weekly radiation doses to personnel in roentgen diagnostic work

Position of chambers	No. of measured dose values	Doses in mr 0—20	21—40	41—60	61—80	81—100	101—300
Chest	97	83	8	2	1	—	3
Hip-pocket	97	85	10	2	—	—	—
Total	194	168	18	4	1	—	3

a

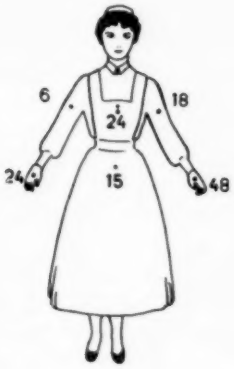

Fig. 1. Skull examination. a) Position of dummy. b) Doses in mr received in examination comprising 5 roentgenograms each with the data 66 to 82 kV, 200 mA, 0.1 sec.

But do these measurements give a true picture of the amount of radiation to which the personnel is exposed? Actually, the radiation milieu in the diagnostic rooms is very heterogeneous. SPIEGLER (8) has shown that the distribution of the scattered radiation to a great extent depends upon the position of the radiation field in relation to the outline of the body. CEDERLUND, LIDÉN, and LINDGREN (3) have given isodose curves around some examination stands showing how these curves depend upon the height above the floor, the shadow effects from the tube stands, and the protective shields for fluoroscopy.

If the chambers are placed only on the chest, any lead-rubber apron will shield the measuring point, leaving other parts of the body unprotected. During fluoroscopy, these chambers will be shielded by the screen, whereas during fluoroscopy with the undercoach tube, for example, the assisting personnel will receive the scattered radiation on the lower parts of the body from the abdomen downwards. The chambers in the hip-pockets are often shielded by the hip itself and by objects in the pockets.

In order to obtain an idea of the radiation doses to which the personnel is exposed, a dummy assistant was used on which up to 13 double chambers were placed. The dummy was flexible at the waist and its arms could take up different positions. In the course of various examinations, it was placed where assisting personnel otherwise stood. These measurements were performed in the Roentgendiagnostic Department of the

Pediatric Clinic of Karolinska Sjukhuset. The dummy did not wear a lead-rubber apron or gloves.

Skull examination. Fig. 1 shows the position of the dummy and the distribution of the radiation received by it. The hands were not in contact with the patient's skull. The radiation doses to the hands varied greatly, depending on the distance between them and the source of scattered radiation. Particularly in skull examinations, it is by no means uncommon for the fingers of the assistant to be visible in the roentgenograms. With the types of lead-rubber gloves now existing it does not seem possible to use them when steadying the head of a baby. Consequently, in unfavourable cases, the radiation dose to the hands approaches the dose to the patient.

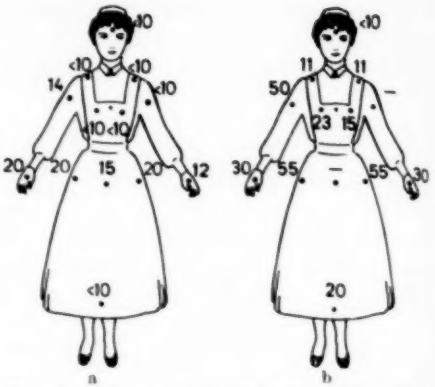

Fig. 2. Colon examination. Dummy replaces person assisting with contrast enema. Doses in mr. a) 1 colon; fluoroscopic data: 90 kV, 2.5 mA, 4.5 min; roentgenographic data: 9 exp., 110 kV, 55 mAs total. b) 2 colons; fluoroscopic data: 90 kV, 2.5 mA, 4.6 min total; roentgenographic data: 21 exp., 110 to 135 kV, 126 mAs total.

Colon. The dummy replaced the person assisting the radiologist with the contrast enema. Two examples of radiation doses to the personnel are shown in Fig. 2. One of them involves 2 consecutive colon examinations. The dummy remained in position during the exposures but, as a rule, the exposures in colon examinations only amount to less than 20 per cent of the totally generated mAs. As mentioned above, the greatest amounts of radiation were found on the lower parts of the body.

Fig. 3. Urethrocystography with biplane film changer. Dummy replaces radiologist making exposures while watching patient.

Urethrocystography with simultaneous exposures in two planes. The position

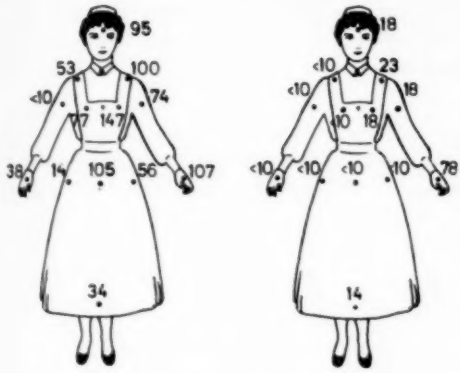

Fig. 4. Urethrocystography with position of dummy as in fig. 3. Doses in mr. a) 105 kV, 200 mA, 0.8 sec, 10 exp. in each plane. b) 80 kV, 350 mA, 0.4 sec, 11 exp. in each plane.

of the dummy is shown in Fig. 3. The dummy replaced the radiologist watching the patient to ensure exposures at the right moment. The physician usually stands behind a protection shield fitted with leadglass but, when the patient is uneasy, he has to be in direct contact with him. Two examples of radiation doses are shown in Fig. 4. The larger dose values not only depend on the different data, but also on the fact that the dummy was closer to the patient. Lower dose values were recorded for the right side of the body than for the left. This was because the tube housing for lateral exposures and its shutters shielded the right part.

Angiocardiography. Fig. 5 shows the position of the dummy. The examinations were performed as described earlier in this paper. The reason for personnel standing here is that they must immediately come to the assistance of the patient in the event of an emergency. Although these examinations sometimes involve more than 100 exposures, none of the measurements at any part of the dummy gave dose values exceeding 10 mr. The low dose values can be explained by the fact that only a few mAs were used at each exposure. For angiocardiography, the patients are anesthetized. During the exposures, the anesthetist must sometimes remain at the head of the patient in order to handle the respiration mask. It seems practically impossible to do this with lead-rubber gloves. Radiation doses between 600 and 1,000 mr per ex-

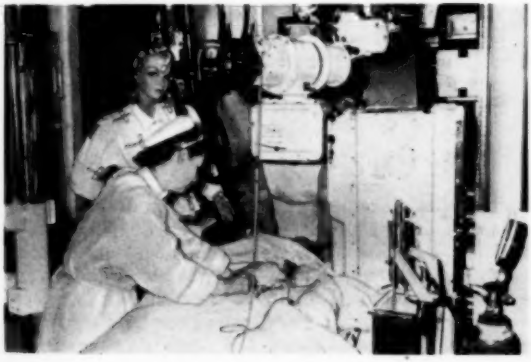

Fig. 5. Angiocardiography with simultaneous roentgenography in 2 directions. Dummy in position of person who must immediately assist patient in an emergency.

amination were measured on the hands of the anesthetist. Particularly in the angiocardiography of small children, the distance between his hands and the radiation fields is very short.

Comments. In view of the heterogeneous radiation milieu in roentgen diagnostic rooms, it seems to me to be unsatisfactory to use only one measuring point to judge whether there are radiation risks to the personnel. If the recorded dose values exceed the highest permissible dose levels, steps will obviously be taken to protect the personnel. But when the recorded doses are small, the work cannot unreservedly be stated to be risk-free. This is because parts of the body may be over-exposured without the doses being recorded.

SUMMARY

Radiation doses received by patients and personnel in certain types of roentgen examinations have been measured. As a rule, the patient receives the largest dose during fluoroscopy when doses exceeding 100 r are not uncommon. A simple rule is given for calculating the patient dose at cardiac catheterization. In planigraphy of the lumbar spine the patient may receive a dose of over 200 r which, by a suitable technique, may be reduced to 2 r. The radiation doses to personnel have been recorded by ionization chambers on the chest and in the hip-pocket; in certain cases dummies have been employed. The measurement of these doses is discussed.

ZUSAMMENFASSUNG

Die Strahlendosen, welchen Patienten und Personal ausgesetzt sind, sind bei gewissen Röntgenuntersuchungen gemessen worden. In der Regel erhält der Patient die höchsten Dosen während der Durchleuchtung. Strahlendosen von über 100 r sind nicht ungewöhnlich. Eine einfache Regel für die Berechnung der Patientdosis bei Herzkatheterisierung wird angegeben. Bei der Planigraphie der lumbalen Wirbelsäule kann der Patient eine Strahlendosis von mehr als 200 r erhalten, diese kann aber bei einer geeigneten Technik bis auf nur 2 r reduziert werden. Die Strahlendosen, die das Personal bei der röntgendiagnostichen Arbeit erhält, sind mit Ionisationskammern an der Brust und in der Hüftengegend gemessen worden. Bei einigen Untersuchungstypen ersetzte eine Attrappe das Personal. Einige Gesichtspunkte über die Messung dieser Strahlendosen werden vorgelegt.

RÉSUMÉ

L'auteur a mesuré, pour certains types d'examens radiologiques, la dose de rayonnement reçue par le malade et par le personnel. En règle, c'est au cours de la radioscopie que le malade reçoit la plus forte dose. Des doses de rayonnement dépassant 100 r ne sont pas exceptionnelles. L'auteur donne une règle simple pour calculer la dose reçue par le malade au cours du cathétérisme cardiaque. Dans la tomographie de la colonne lombaire, le malade peut recevoir une dose dépassant 200 r, mais l'emploi d'un procédé convenable permet de réduire cette dose à 2 r seulement. Les doses de rayonnement reçues par le personnel ont été mesurées au moyen de chambres d'ionisation placées sur la poitrine et dans la poche à revolver. Pour certains types d'examens, un mannequin remplaçait le personnel. L'auteur émet quelques idées sur la mesure des doses de radiations.

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SOME MEASUREMENTS OF SCATTERED RADIATION FROM ROENTGEN DIAGNOSTIC BEAMS

by

Jon Flatby and *Sem Maudal*

During recent years much attention has been paid to the problem of the radiation hazard in roentgen diagnostics, and various papers have appeared in the literature on this subject. Direct measurement of the dose received by the radiologist during different kinds of diagnostic work has been performed by COWING and SPALDING (1949), GLOCKER (1950), JACOBSEN, SCHWARTZMAN and HEISER (1952), HIMANKA and LORENTZON (1954). Other investigators have concentrated their work on establishing the scattered dose rate and isodose curves around different types of roentgen stands. Such measurements have been undertaken by BINKS (1943), MORGAN and LEWIS (1946), SPIEGLER and KEANE (1951, 1955), and HENNY (1955). Just after finishing the experimental part of our investigations, CEDERLUND, LIDÉN and LINDGREN (1955) published a paper comprising the result of an extensive survey of isodose curves, in different sections around an undercouch and a vertical stand.

The programme for our investigations of scattered roentgen radiation was:

1. To establish the distribution of scattered dose rate in a diagnostic room.

2. To investigate especially the radiation field behind and in closest vicinity of the fluoroscopic screen, with and without side-screens attached. Such measurements are of interest, because the upper part of the body of the fluoroscopist (shoulders, head) is generally unshielded and consequently may be overexposed outside the 'safety zone'. To a greater extent this may, of course, apply to persons (physicians, nurses, etc.) stationed next to the fluoroscopist during the roentgen examination.

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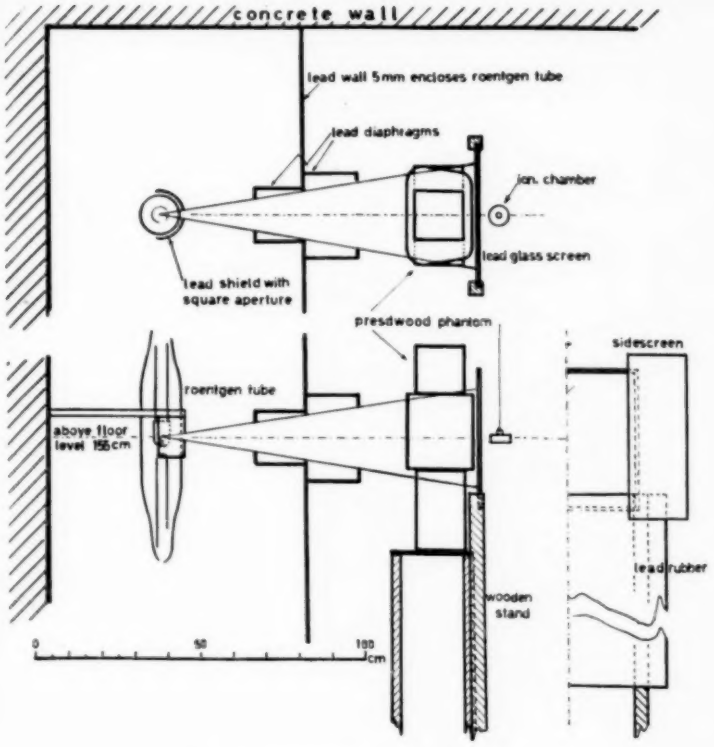

Fig. 1. Experimental arrangement.

3. To register the influence of a nearby wall on the dose rate behind the screen and the effect of partly covering this wall with an iron plate.

Our interest was especially directed towards the factors mentioned under items (2) and (3).

Experimental arrangement. Due to the comparatively long time necessary for accomplishing the experiments planned, the occupation of certain diagnostic installations at our hospital was difficult to arrange. We have at our disposal in the laboratory, on the other hand, a Siemens Stabilivolt therapy machine, and the experiments were carried through with this machine. The arrangement which was used is shown in Fig. 1, and in Fig. 5 a general view of the laboratory room. The S.R.W. Do. 200/6 roentgen tube, in a lead protective shield, was placed in the corner of the room. A suitable field size and adequate limitation of the beam

was attained by means of three diaphragms, in addition to that represented by the lead wall itself, set up as shown in Fig. 1. The diaphragms were made of 3 mm lead and adjusted to give a field size of 30 × 32 cm on the fluoroscopic screen.

The hardboard phantom consisted of three parts, roughly representing the head, thorax, and abdomen of the body, and measuring 15 × 15 × 15 cm, 20 × 30 × 23 cm and 15 × 30 × 25 cm, respectively. The target—surface distance of the thorax phantom was 75 cm, and the target—screen distance 96 cm. We used a S.R.W. Super Astral leadglass screen with a lead equivalent of 2.24 mm and measuring, including a 1.5 cm frame, 43 × 43 cm, fixed in a simple way to a wooden stand. On account of the stand being close to the wall, which was of concrete (the distance to the screen centre was only 57 cm) this was considered suitable for demonstrating scattering effects on the dose rate behind the screen.

Some of the measurements were performed with side-screens of 1 mm lead, reaching 15 cm outside the edge of the fluoroscopic screen, and with a lead rubber apron 60 × 100 cm, of a lead equivalent of 0.6 mm, attached to the screen.

The dose measurement was accomplished with 8 similar ionization chambers of 70 cm^3 volume and with 1.5 mm bakelite walls. For charging, and for the reading of the doses, the chambers were connected with a Moxnes Electrometer in the usual way. The chambers were capable of registering doses limited upwards to about 40 mr. Each was calibrated separately for secondary radiation by means of a 0.5 r Moxnes thimble chamber, and the individuality of the chambers was taken into account. Serving both as a support for the ionization chambers, and as a co-ordinate system, iron wires were stretched parallel to the screen, at a horizontal level well above the top of the phantom. The wires were, with one exception, arranged at intervals of 20 cm in the neighbourhood of the screen. In the longitudinal direction of the wires, the distance between adjacent chambers was generally 30 cm. The length of the thin threads, attaching the chambers to the iron wires, was exactly regulated to give dose measurements in the equatorial level (horizontal plane containing central beam and centre of fluoroscopic screen). The accuracy of the measurements is estimated to about 4 to 5 per cent.

The roentgen tube was run at 80 kV and 3.0 mA D. C. Inherent filtration of the tube was 1.5 to 2.0 mm Al (approx.); no additional filter was used, and the H.V.L. for the generated radiation was 1.86 mm Al. At a target distance of 75 cm, *i.e.* at the surface of the thorax phantom facing the roentgen tube, the dose rate measured in air was 3.50 r/min. Some dose measurements along the horizontal symmetry axis of the field revealed no intensity variations exceeding the limit of accuracy in the measurements, which was about 3 per cent.

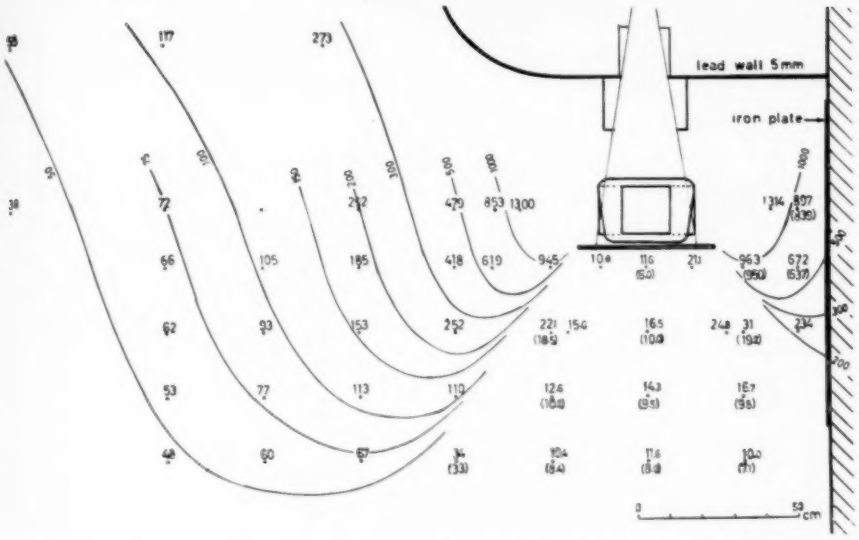

Fig. 2. Scattered dose rate in mr/hour around vertical stand at the horizontal symmetry level for primary beam and screen. Numbers in brackets refer to measurements with an iron plate covering concrete wall next to stand; no side-screens or lead-rubber apron.

The setting up of the phantom was performed very carefully to avoid any asymmetry in the arrangement. A search for leakage radiation was also undertaken; the diaphragm next to the phantom was covered with lead and tests were made with a suitable Geiger counter. No leakage was found.

Results of measurements. The experimental results are presented in Figs. 2 to 5. The numbers given at the points of measurement, and at the isodose curves, indicate the dose rate in mr/hour. As mentioned, the primary beam was generated at 80 kV and 3.0 mA D.C. All observations refer to the horizontal symmetry level for primary radiation field and screen. For the purpose of giving a clear presentation of 'the shadow' behind the screen, no isodose curves are drawn in this section.

Fig. 2 shows the dose rate when the fluoroscopic screen is without side-screens and no lead rubber hangs from its lower edge. To avoid any misunderstanding it must be emphasized that in this case the radiation field at the symmetry level is naturally not representative of the entire three-dimensional field in front of the roentgen stand. According to some measurements made by us, the dose distribution outside the shadow zone in the vertical symmetry plane is roughly given by that

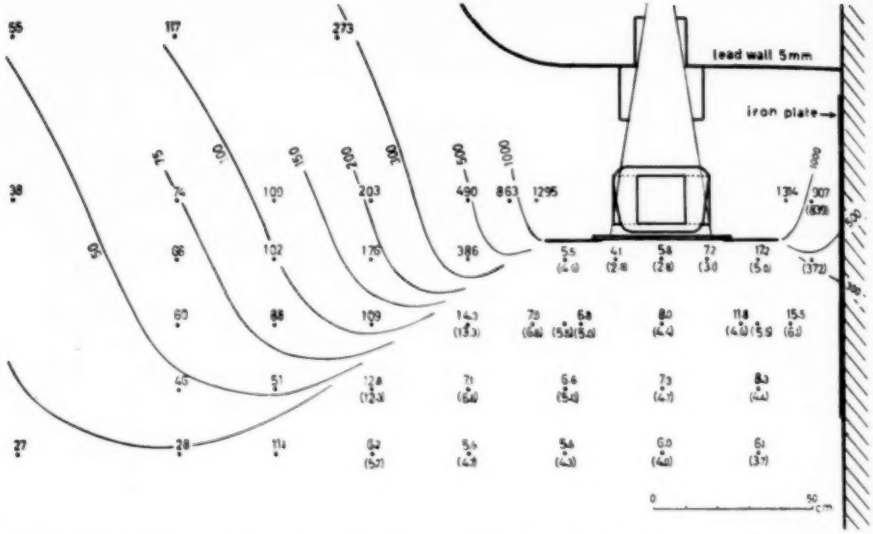

Fig. 3. Same arrangement as in fig. 2, with exception that side-screens and lead-rubber apron have been attached to the fluoroscopic screen. Dose rate in mr/hour at horizontal symmetry level.

in the horizontal one, when the dose rates are reduced to a value of about 15 to 20 per cent of those given there. It is obvious, consequently, that the fluoroscopist must be protected at least by a lead-rubber apron. We are, however, not dealing with these important questions in this paper but have limited ourselves to certain problems, mentioned earlier, in which the knowledge of the dose rate at the level of the screen is of interest.

The measurements were undertaken both with and without an iron plate, measuring 100×200 cm (3 mm thick), covering the concrete wall on the right side of the stand. Where a noticeable difference in the dose rate was established, the point of measurement is supplied with two numbers, the one in brackets referring to measurements with the iron-covered wall.

Fig. 3 shows similar measurements when side-screens were attached to the fluoroscopic screen. In addition, a 60×100 cm sheet of lead-rubber was fixed to the screen to attain the most favourable conditions with respect to side-scattering into the shadow zone (Fig. 1). This large sheet was meant to give approximately the same shielding effect as the usual combination of lead-rubber apron, hanging from the screen, and protected chair.

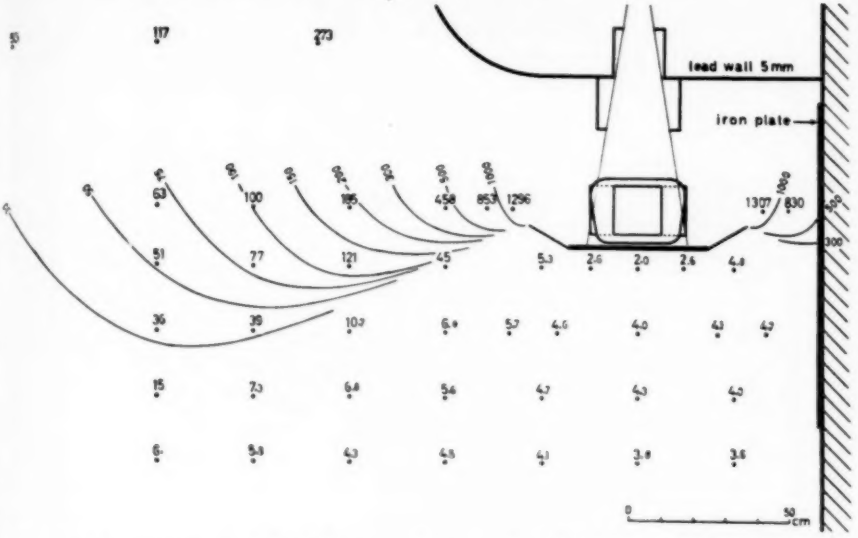

Fig. 4. Side-screens attached to fluoroscopic screen bent 30° backwards. Measurements taken only with iron-covered wall, otherwise same arrangement as in fig. 3. Dose rate given in mr/hour at horizontal symmetry level.

In Fig. 4, the 15 cm wide side-screens are bent 30° backwards. In this case, measurements were only taken with the iron plate on the wall. Fig. 5 gives the equatorial radiation field in the 'diagnostic room' The iron plate was omitted in this case.

Discussion

As to the dose rate distribution in the diagnostic room (Fig. 5), the high intensities in the rear part of the room seem at first a little surprising, and leakage radiation might have been suspected to occur in this part of the room, but this possibility was ruled out after tests with a Geiger counter. What we have established is the well-known high intensity backscattering. It is, of course, easier to demonstrate this effect with a real diagnostic installation, where measurements can be taken on all sides of the roentgen tube (CEDERLUND et coll., MORGAN and LEWIS, and SPIEGLER and KEANE).

The side-screens (and lead-rubber apron) have the double effect of extending the shadow zone and reducing sidescattering into this zone. The first effect is clearly demonstrated in Figs. 2, 3, and 4. At the surface of the screen, a dose rate of only about 0.5 mr/hour is due to direct penetration of radiation through the lead-glass. As the dose rates measured

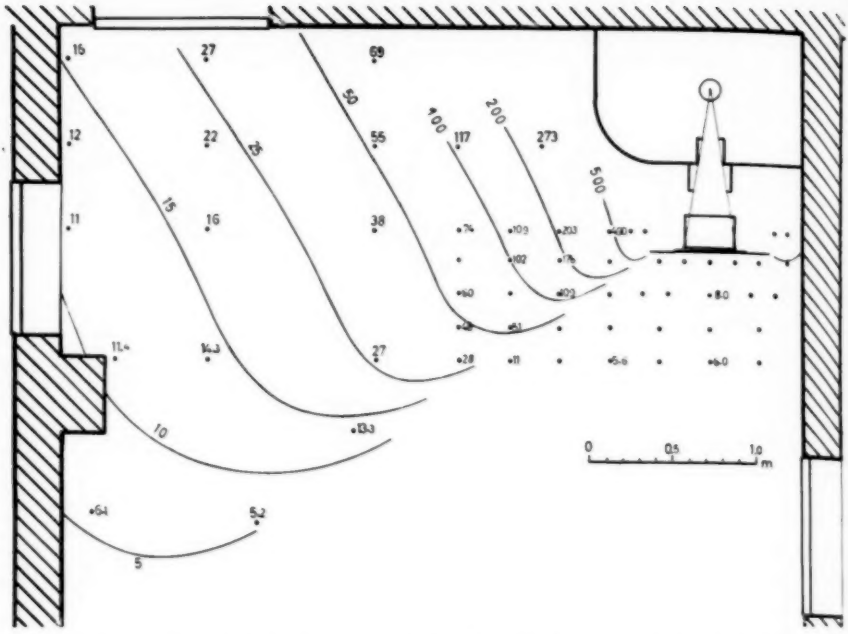

Fig. 5. Dose rate distribution in the 'diagnostic room'. Dose rate given in mr/hour at horizontal symmetry level of side-sereens and lead-rubber aprons. No iron plate on concrete wall.

in the shadow zone are essentially higher, it must be concluded that sidescattering is the predominant effect in building up the dose rate in this section. (At higher voltages the radiation is more penetrating, but the shielding effect of the screen should always be so chosen as to give a direct beam intensity in front of it which is small as compared with a reasonable dose rate due to sidescattering). Consequently, all objects struck by the secondary radiation from the phantom, *i.e.* walls, floor, ceiling etc., as well as the air, are more or less responsible for the dose rate observed.

We now intend to consider the scattering effect of the concrete wall on the right side of the stand. As will be seen in Figs. 2 and 3, there is a pronounced asymmetry in the radiation field behind the screen (not resulting from any asymmetry of the primary field or in the arrangement of the screen and phantom). It is reasonable to assume that the asymmetry observed is due to scattering from the wall. In order to reduce this scattering we covered the wall with 3 mm of iron. According to investigations by WALSTAM (1954) and by LINDELL (1954), iron gives

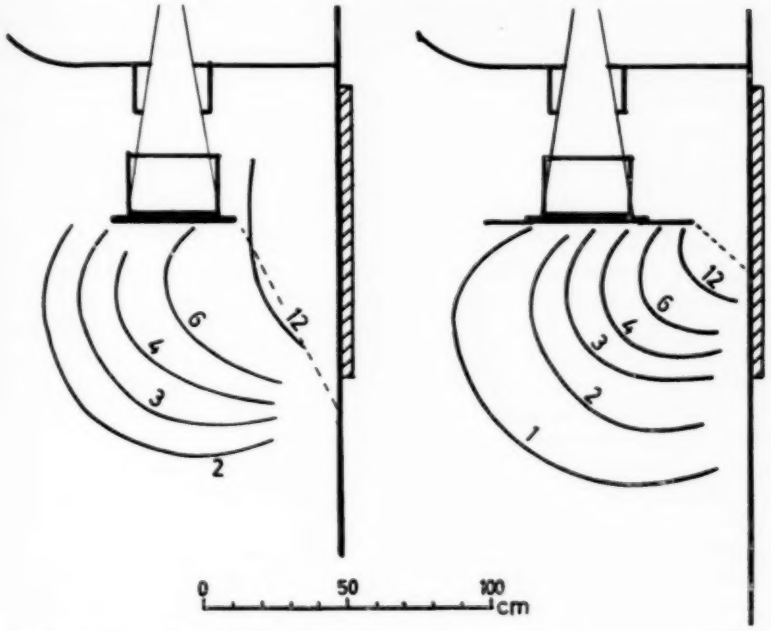

Fig. 6. Difference between scattered dose rates, with concrete wall uncovered, and respectively with the hatched part covered with iron. Due to the small scattering from iron, the isodose curves represent approx. the scattering from the hatched part of the concrete wall. Dose rate given in mr/hour at horizontal symmetry level.

a lower secondary dose rate than any other ordinary element. This is because the absorption in iron of the roentgen radiation normally used is mainly due to the photoelectric effect, while at the same time the 7 kV characteristic K-radiation generated is highly absorbable. If, for instance, we compare the reflected energy from aluminium and iron, when exposed to 50 kV monochromatic radiation, an estimate based upon a simple mathematical integration and knowledge of the absorption coefficients shows that about six times as much energy is scattered (Compton effect) by aluminium as compared with iron. The energy carried away by the fluorescence rays is for iron only about 5 to 10 per cent of the total reflected energy. This soft radiation will consequently only give a small integral dose. As its absorption takes place in the region of the skin, it may be supposed that the biologic effect of this radiation is negligible. According to some special measurements made by us, this fluorescence radiation was practically not registered with the ionization chambers used in our investigations.

The influence of the iron plate upon the radiation field behind the screen is demonstrated in Figs. 2 and 3. As will be seen, the reduction of the dose rate is appreciable.

The above estimate made for aluminium and iron should be approximately representative for concrete and iron in our experiments. The scattered dose rate from the concrete wall will then, as a rough first approximation, be given by the difference between the two numbers at each point of measurement. The accuracy of this value is of course not very great. The result of such a procedure is shown in Fig. 6. The section of the wall responsible for the scattered dose rate given, is hatched; the dotted lines indicate the boundary of the secondary radiation field.

In the case where side-screens are attached to the fluoroscopic screen, only a fraction of the hatched part of the wall is hit by the secondary radiation. At the same time the side-screens (here the right one) give a better shielding against the radiation scattered from the wall. The result of these effects may be studied in Fig. 6.

The general trend of the isodose curves in this figure seems to indicate that the dose rate scattered from a wall into regions at distances of 1.5 to 2.0 m from it, is not likely to exceed a value of about 1 mr/hour. The radiation scattered from the walls on the left side of the stand produces therefore in our experiments only a small contribution to the dose rate behind the screen. The influence of the lead shield of the roentgen tube, the floor, and the ceiling, is not easy to establish without special experiments. The scattering from the ceiling and floor, however, is likely to be essentially smaller than that from the wall we have been dealing with (smaller intensity, greater distance). To furnish an account of the various contributions to the dose rate observed is difficult, but it seems likely that scattering from the air must also be considered. The importance of the side-screens for the reduction of air-scattering into the shadow zone is evident.

From Figs. 2 to 4 we may state that the attachment of side-screens and lead-rubber apron to the fluoroscopic screen has reduced the side-scattering to about half its original value. The main purpose of the side-screens is, of course, to increase the shadow zone, but the reduction of the sidescattering is also important and should claim our attention.

We used a 3 mm thick iron plate in our experiments. For a primary beam generated at 80 kV, an iron thickness of 2 mm will probably suffice, possibly 1 mm will do. This and other problems are to be tackled in later experiments.

Acknowledgments

We wish to express our gratitude to N. H. Moxnes, Director of The State Institute of Radiophysics, Oslo, and to F. Marstrander, Director of The Roentgen Department, Bodø Hospital, for many inspiring discussions concerning our experiments.

SUMMARY

Some measurements of the scattered dose rate around a roentgen vertical stand demonstrate the influence of side-screens attached to the fluoroscopic screen. The effects obtained are: an increased shadow zone behind the fluoroscopic screen and reduced side-scattering into this zone. The dose rate scattered from a concrete wall next to the stand is determined and shown to be considerably reduced when the wall is covered with iron.

ZUSAMMENFASSUNG

Einige Messungen der Streustrahlenleistung um ein stehendes Röntgengerät zeigen den Einfluss der seitlichen Abschirmung, die am Leuchtschirm angebracht wurde. Die Schattenzone hinter dem Leuchtschirm nimmt zu, und die seitliche Streustrahlung in der Nähe dieser Zone nimmt ab. Die Messungen der Streustrahlung von einer Betonwand neben dem Gerät zeigte, dass diese Streustrahlung merkbar herabgesetzt wird wenn die Wand mit Eisen bedeckt ist.

RÉSUMÉ

Des mesures du rayonnement diffusé autour d'un statif radiologique vertical montrent l'influence d'écrans latéraux attachés à l'écran radioscopique. Leur effet est d'agrandir la zone d'ombre derrière l'écran radioscopique, et, de plus, de réduire la diffusion latérale dans cette zone. Les auteurs ont mesuré le rayonnement diffusé par un mur de béton voisin du statif. Ce rayonnement est diminué de facon appréciable quand le mur est revêtu de fer.

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BOOK REVIEWS

PEDIATRIC X-RAY DIAGNOSIS. A textbook for students and practitioners of pediatrics, surgery, and radiology. By John Caffey. 1,059 pp., 1,267 figs. 3rd edit. The Year Book Publishers, Inc., Chicago 1956. U. S. Doll. 28: —

The third edition of this well-known work on paediatric roentgen diagnosis has now appeared scarcely six years after the second edition. Some sections have been revised, and others have been completely rewritten. A total of 383 new figures have been added. The number of pages has been increased by almost 200.

Among the sections with entirely new text, particular interest is aroused by the account of the roentgenologic findings in congenital dislocation of the hip-joint. The author has made a detailed analysis of normal variations in the roentgenologic anatomy of the hip-joint in infants, from which he has been able to show that the current conception of a stage of predislocation is unsupported by roentgenologic evidence. The considerable normal range of variation in the acetabular angle makes it necessary to be extremely cautious in making a roentgenologic diagnosis of dislocation of the hip-joint in infants. Among the other rewritten sections are those on coxa plana and on slipping of the upper femoral epiphysis.

Elgenmark's table for the calculation of the degree of skeletal maturity are included, and the findings in recent longitudinal studies of skeletal development are taken into account. Entirely new features in this edition are the sections on the diagnosis of multiple epiphyseal dysplasia, oxalosis of the skeleton, multiple metaphyseal dysostosis and hypophosphatasemia, and Milkman's syndrome, all of which are highly instructive and well illustrated.

The urologic chapter has been greatly improved by numerous illustrations. The technique and findings in urethrography are described in more detail than in earlier editions.

The section on congenital heart disease has been completely revised, but no account of Ebstein's disease is given; illustrations of the main types of transposition of the great vessels are also lacking. Instructive schematic diagrams of changes in haemodynamics greatly facilitate the interpretation of roentgenologic observations in various conditions. The majority of angiocardiograms are of the venous type, although the selective technique is mentioned as being a more accurate method.

In the section on the respiratory organs, the parts on atelectasis and collapse of the lungs are among those enlarged. A brief account is given of the roentgenologic findings in the interesting disease of familial autonomic dysfunction. As far as the technique is concerned, one looks in vain for an opinion on the value of adequately exposed frontal films for the demonstration of retrocardiac lesions.

The partially thoracic stomach with a short oesophagus, oesophageal ulcer, and transdiaphragmatic duplication of the gastrointestinal tract are dealt with in detail.

The bibliography, based mainly on American publications, is most comprehensive and up-to-date. To sum up, this new edition stands out to an even higher degree than the earlier ones as the most outstanding and authoritative text and reference book on paediatric roentgen diagnosis.

Ulf Rudhe.

RADIOLOGY PHYSICS. An introductory course for radiologists, radiographers and medical students. By John Kellock Robertson. Third edition. 330 pp., 191 figs., 27 tables. Macmillan & Co., London 1956. 36 sh.

As indicated by the sub-title, this book is of elementary character and seems well suited to the needs of the two last-mentioned categories of readers; radiologists, however, should not expect to find much that is new to them. The matter is treated in a simple and easy-to-follow manner, and the reader is not supposed to have more than elementary knowledge of physics and mathematics. In view of this, the large scope of the subject matter, and the limited space available, it is natural that the treatment is neither thorough nor detailed. For example, only simplified wiring diagrams of the more common types of roentgen machines are given; three-phase six valve apparatus, which is certainly important, is not even mentioned.

In the first two chapters, the electrotechnical principles of roentgen machines are developed. The four following chapters deal with gas discharges, cathode and positive rays, roentgen tubes and rectifiers. Four more chapters describe the general properties of roentgen rays, absorption effects, and secondary radiations, together with some roentgenographic applications. A chapter on dosimetry is followed by chapters on natural radioactivity, various accelerators, transmutation of matter and neutrons, artificial radioactivity, and nuclear reactors. A short appendix on radiation protection and a few tables conclude the book. A number of problems are included in most of the chapters, enabling the student to test his assimilation of the text. The solutions in several cases, however, unfortunately appear to be inaccurate.

Sven Benner.

DAS SKELETT DES KINDES. Entwicklung, Bildungsfehler und Erkrankungen. Von W. Swoboda. 184 S. 199 Abb. Georg Thieme Verlag, Stuttgart 1956. DM 48. —

According to the author, this work is addressed mainly to the paediatrician but is also intended to serve as a guide, among others, to the roentgenologist, in the diagnosis of diseases and developmental anomalies of the skeleton in children.

By way of introduction, a description is given of the clinical and patho-anatomic background of roentgenologic examinations in childhood. Next section deals with the roentgenologic diagnosis of the growing skeleton under normal and mildly pathologic conditions. The main part of the book comprises an account of the genetically determined skeletal anomalies, and of the changes occurring on the basis of endocrine, metabolic, inflammatory and toxic disturbances, as well as of the diseases of the reticuloendothelial system affecting the skeleton. Bone tumours are briefly dealt with. As far as fractures are concerned, only a few are mentioned. The major part of the text is devoted to clinical aspects and morbid anatomy. The accounts of roentgenologic findings are concise, and they are generally confined to typical cases.

The illustrations consist almost exclusively of reproductions of roentgenograms, supplemented by diagrams and schematic drawings. The illustrative material is of high quality throughout, and the points enumerated in the legends are clearly visualized.

Very few details are given regarding techniques used in roentgenologic examinations, and errors of interpretation due to technique are only exceptionally mentioned. From the roentgenologic point of view, the book is presumably most serviceable as an introduction to the symptomatology of skeletal disorders. The value of the book is enhanced by the numerous references to both European and American publications.

Ulf Rudhe.

Röntgenaufnahmetechnik in der Hals-Nasen-Ohren-Heilkunde. Von Burkhard Schlosshauer. Georg Thieme Verlag, Stuttgart 1956. 48 S. 72 Abb. DM 12: —

This manual for radiographers is based on the use of the Lysholm skull-table. For each projection, the roentgenologic anatomy is first briefly outlined, and this is followed by a description of the mistakes which are most commonly made. Finally, the directions for obtaining an ideal image are given. These include not only positioning of the head, in relation to the table top and its centering cross, and the direction of the central ray, but also the point of entry of the central ray is indicated. When the author, as is the case in several instances, indicates the hairline of the forehead as the point of entry, this must be regarded as entirely misleading.

For many projections, the author has omitted to give directions for angling of the tube in two planes, which implies that the head must instead be turned obliquely against the table top. This seems an inadequate deviation from the guiding principles for the use of the skull-table.

The book is as complete as could be wished with respect to the projections required for the examination of the ear, and of the nasal sinuses. However, only the lateral view is described for the nasal bones, but for these the axial and half-axial projections will be required as well, in cases of fractures.

Bror Brodén.